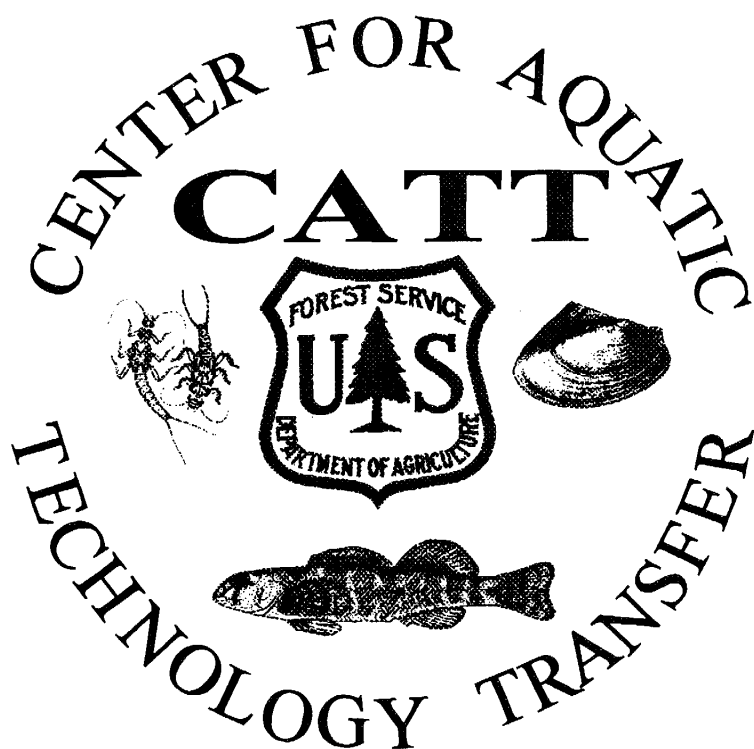


**An Inventory of Stream Habitat in the Nantahala River Watershed,  
Nantahala National Forest, North Carolina**



United States Department of Agriculture Forest Service  
**Center for Aquatic Technology Transfer**  
Department of Fisheries and Wildlife Sciences  
Virginia Tech, Blacksburg, VA 24061-0321

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June 1999

<sup>1</sup> The Center for Aquatic Technology Transfer is jointly sponsored by the Southern Research Station, Coldwater Fisheries Research Unit (Unit Leader - C. Andrew Dolloff) and the Southern Region (Region 8) of the USDA Forest Service.

## **Introduction**

In Summer 1998 basinwide visual estimation techniques (BVET)(Hankin and Reeves 1988; Dolloff et al. 1993) were used to quantify current stream conditions in the Nantahala River Watershed (NRW), Nantahala National Forest, North Carolina. The use of BVET allowed us to estimate total habitat area, percentage of pool and riffle area, water depth, and classify the stream substratum particle size distribution. We also inventoried and mapped the distribution of large woody debris (LWD). In this report we describe the current baseline conditions of habitat in the NRW which includes ten tributaries along with the Nantahala River itself.

## **Study Streams**

A total of 27.7 kilometers of stream habitat was surveyed in the NRW. The survey of the Nantahala River began at the lower U.S. Forest Service boundary and continued over 11.7 kilometers upstream to the confluence with Kilby Creek (Figure 1). We surveyed almost 4.9 kilometers of Kimsey Creek, over 3.2 kilometers of Park Creek, approximately 3.2 kilometers of Mooney Creek, and over 1.8 kilometers of Big Indian Creek; all starting at each streams confluence with the Nantahala River (Figure 1). The five smaller tributaries which were also sampled included Kilby Creek (1.0 kilometers), Long Branch(0.9 kilometers), Devils Prong (0.9 kilometers), Little Indian Creek (0.6 kilometers), and Yellow Patch Branch (0.2 kilometers) (Figure 1).

## **Methods**

We used two-stage visual estimation techniques to quantify habitat in the study

streams. During the first stage, one crew member identified each habitat unit by type (pool or riffle), estimated wetted stream width, and estimated the maximum, average, and pool-riffle crest depth of each habitat unit. The remaining crew member classified and inventoried LWD (within the active stream channel), estimated the percentage of substrate in distinct size classes (Modified Wentworth Scale) (Table 1), and recorded the data on waterproof paper.

LWD was divided into four size classes: 1) less than 5m long, less than 55 cm in diameter, 2) less than 5m long, greater than 55cm in diameter, 3) greater than 5m long, less than 55cm in diameter, and 4) greater than 5m long, greater than 55cm in diameter. All LWD less than 1m long and less than 10cm in diameter were omitted from the survey. Maximum depth was measured and average depth of each habitat unit was estimated by taking depth measurements at various places across the channel profile, with a graduated staff marked in 5-cm increments. Pool-riffle crest depth was measured at the deepest point, within the thalweg, at the hydraulic control between the tail of a pool and the crest of a riffle. The length (0.1m) of each habitat unit was measured with a hip chain.

The first unit of each habitat type selected for intensive sampling (accurate measurement of surface area - second stage sampling) was determined randomly. Additional units were selected systematically (about one unit out of 20 for each habitat type). This two stage sampling protocol, used to calibrate the percent substrate estimates, corrected for caller bias in the first stage of sampling. During the first stage of sampling, we estimated substrate composition based on the percentage of stream bottom occupied by particles in each size class in every habitat unit. When a habitat



unit was selected for measurement (second stage), a pebble count (similar to the pebble count described in Harrelson et al. 1994) was performed. Pebble counts for each substrate particle size class were converted into percentages to permit comparison with the callers estimates. This gave us the paired samples needed to develop correction factors, variance, and corrected estimates with 95% confidence intervals for substrate composition in each habitat type for all streams surveyed.

BVET calculations were computed and data were summarized using a Quattro Pro spreadsheet, SigmaPlot graphics software, SigmaStat statistical software, and WordPerfect.

## **Results**

### **Nantahala River**

We identified 108 pools and 102 riffles in the Nantahala River study section. Visual estimates of habitat area were paired with measured habitat area for 8 (8 %) pools and 7 (7 %) riffles. We estimated that the Nantahala River study section contained 14.8 % pool habitat ( $19,181.9 \pm 1,235.9 \text{ m}^2$ ) and 85.2 % riffle habitat ( $110,010.3 \pm 22,094.5 \text{ m}^2$ ) (Figure 2). Total area was estimated for each habitat type using correction factors ( $\hat{Q}$ ) that ranged from 0.80 to 0.81.

Mean maximum depth and mean average depth for pools was 76.5 cm and 50.4 cm, respectively (Figure 3). As expected, the ranges of maximum and average depths for riffles were significantly shallower than the ranges of maximum and average depths for pools,  $p < 0.05$  (Figure 3). The mean average residual pool depth in the Nantahala River study section was 26.5 cm (Figure 3).

We identified cobble and gravel as the most common dominant (covering the greatest percentage of the stream bottom) and subdominant (covering the second greatest percentage of the stream bottom) substratum, respectively, in pool type habitat of the Nantahala River study section (Figure 4). The composition of substrate in riffles was similar to that found in pools with the exception of less silt (Figure 5). The corrected substratum estimates were based on correction factors that ranged from 0.40 to 1.85.

The Nantahala River contained about 48 pieces of LWD per kilometer (Figures 6 and 7). This section contained about 12 pieces per kilometer of the larger size classes which are the most stable and most capable of forming instream habitat and providing cover for fishes (Figure 7).

### **Kimsey Creek**

We identified 68 pools and 70 riffles in the Kimsey Creek study section. Visual estimates of habitat area were paired with measured habitat area for 4 (6 %) pools and 4 (6 %) riffles from the Kimsey Creek study section. We estimated that the Kimsey Creek study section contained 10.9 % pool habitat ( $2,175.0 \pm 443.7 \text{ m}^2$ ) and 88.4 % riffle habitat ( $17,768.3 \pm 1,481.6 \text{ m}^2$ ) (Figure 8). Total area was estimated for each habitat type using correction factors ( $\hat{Q}$ ) that ranged from 1.12 to 1.25.

Mean maximum depth and mean average depth for pools was 47.0 cm and 23.1 cm, respectively (Figure 9). As expected, the ranges of maximum and average depths for riffles were significantly shallower than the ranges of maximum and average depths for pools,  $p < 0.05$  (Figure 9). The mean average residual pool depth in the Kimsey

Creek study section was 6.0 cm (Figure 9).

We identified cobble and sand as the most common dominant and subdominant substratum, respectively, in pool type habitat of the Kimsey Creek study section (Figure 10). The dominant and subdominant substrata for riffles, however, were cobble and gravel respectively (Figure 11). The corrected substratum estimates were based on pooled correction factors, which ranged from 0.57 to 1.23.

Kimsey Creek contained about 71 pieces of LWD per kilometer (Figures 12 and 13). This section contained about 15 pieces per kilometer of the larger size classes which are the most stable and most capable of forming instream habitat and providing cover for fishes (Figure 13).

## **Park Creek**

We identified 40 pools and 41 riffles in the Park Creek study section. Visual estimates of habitat area were paired with measured habitat area for 2 (5 %) pools and 2 (5 %) riffles from the Park Creek study section. We estimated that the Park Creek study section contained 12.6 % pool habitat ( $1,142.5 \pm 1,047.9 \text{ m}^2$ ) and 87.4 % riffle habitat ( $7,907.1 \pm 5,101.7 \text{ m}^2$ ) (Figure 14). Total area was estimated for each habitat type using correction factors ( $\hat{Q}$ ) that ranged from 1.00 to 1.20.

Mean maximum depth and mean average depth for pools was 52.3 cm and 21.8 cm, respectively (Figure 15). As expected, the ranges of maximum and average depths for riffles were significantly shallower than the ranges of maximum and average depths for pools,  $p < 0.05$  (Figure 15). The mean average residual pool depth in the Park Creek study section was 5.4 cm (Figure 15).

We identified cobble and gravel as the most common dominant and subdominant substratum, respectively, in pool type habitat of the Park Creek study section (Figure 16). The dominant and subdominant substrata for riffles were the same as found in pools (Figure 17). The corrected substratum estimates were based on pooled correction factors from six streams that ranged from 0.31 to 2.60. Due to the high variance of this sample these results should be used with discretion.

Park Creek contained about 77 pieces of LWD per kilometer (Figures 18 and 19). This section contained about 6 pieces per kilometer of the larger size classes which are the most stable and most capable of forming instream habitat and providing cover for fishes (Figure 19).

### **Mooney Creek**

We identified 50 pools and 49 riffles in the Mooney Creek study section. Visual estimates of habitat area were paired with measured habitat area for 3 (6 %) pools and 3 (6 %) riffles from the Mooney Creek study section. We estimated that the Mooney Creek study section contained 21.4 % pool habitat ( $1,940.2 \pm 2,353.2 \text{ m}^2$ ) and 78.6 % riffle habitat ( $7,108.9 \pm 9,892.4 \text{ m}^2$ ) (Figure 20). Total area was estimated for each habitat type using correction factors ( $\bar{Q}$ ) that ranged from 1.07 to 1.13.

Mean maximum depth and mean average depth for pools was 59.7 cm and 38.1 cm, respectively (Figure 21). As expected, the ranges of maximum and average depths for riffles were significantly shallower than the ranges of maximum and average depths for pools,  $p < 0.05$  (Figure 21). The mean average residual pool depth in the Mooney Creek study section was 19.7 cm (Figure 21).

We identified cobble and gravel as the most common dominant and subdominant substratum, respectively, in pool type habitat of the Mooney Creek study section (Figure 22). The dominant and subdominant substrata for riffles, however, were cobble and small boulder respectively (Figure 23). The corrected substratum estimates were based on pooled correction factors from three streams that ranged from 0.61 to 1.50.

Mooney Creek contained about 89 pieces of LWD per kilometer (Figures 24 and 25). This section contained about 22 pieces per kilometer of the larger size classes which are the most stable and most capable of forming instream habitat and providing cover for fishes (Figure 25).

### **Big Indian Creek**

We identified 33 pools and 33 riffles in the Big Indian Creek study section. Visual estimates of habitat areas were paired with measured habitat area for 2 ( 6 %) pools and 2 ( 6 %) riffles from the Big Indian Creek study section. We estimated that the Big Indian Creek study section contained 15.1 % pool habitat (  $732.9 \pm 1,145.5 \text{ m}^2$  ) and 84.9 % riffle habitat (  $4,115.1 \pm 60.3 \text{ m}^2$  ) (Figure 26). Total area was estimated for each habitat type using correction factors ( $\hat{Q}$  ) that ranged from 1.12 to 1.15.

Mean maximum depth and mean average depth for pools was 43.5 cm and 21.8 cm, respectively (Figure 27). As expected, the ranges of maximum and average depths for riffles were significantly shallower than the ranges of maximum and average depths for pools,  $p < 0.05$ . The mean average residual pool depth in the Big Indian Creek study section was 6.3 cm (Figure 27).

We identified gravel and cobble as the most common dominant and subdominant substratum, respectively, in pool type habitat of the Park Creek study section (Figure 28). The dominant and subdominant substrata for riffles, however, were cobble and gravel respectively (Figure 29). The corrected substratum estimates were based on pooled correction factors from six streams that ranged from 0.82 to 1.14. Due to the high variance of this sample these results should be used with discretion.

Big Indian Creek contained about 75 pieces of LWD per kilometer (Figures 30 and 31). This section contained about 9 pieces per kilometer of the larger size classes which are the most stable and most capable of forming instream habitat and providing cover for fishes (Figure 31).

### **Other Tributaries**

The five remaining tributaries: Kilby Creek, Long Branch, Devils Prong, Little Indian Creek, and Yellow Patch Branch were also summarized. Corrected habitat surface area estimates and corresponding 95% confidence intervals for all five tributaries are located in Table 2. Kilby Creek is summarized in Figures 32 through 37, Long Branch is summarized in Figures 38 through 43, and Devils Prong is summarized in Figures 44 through 49. Little Indian Creek is summarized in Figures 50 through 55 and Yellow Patch Branch is summarized in Figures 56 through 61.

### **Literature Cited**

- Dolloff, C. A., D. G. Hankin, and G. H. Reeves. 1993. Basinwide estimation of habitat and fish populations in streams. General Technical Report SE-83. Asheville, North Carolina: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experimental Station. 25 pp.
- Hankin, D. G. and G. H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences. 45: 834-844.
- Harrelson, Cheryl C., Rawlins, C. L., Potyondy, John P. 1994. Stream channel reference sites: an illustrated guide to field technique. Gen. Tech. Rep. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61p.

### **Acknowledgments**

We would like to thank the following people for their contributions to this report: Lisa Whitaker, Sam Whitaker, Tom Brady, and Chris Ford. The substrate composition inventory used in this project was developed with assistance from Richard Burns (Forest Hydrologist - National Forests of North Carolina).

Table 1. Substrate classification criteria.

<b>SUBSTRATE CLASSES</b>		
<b><u>Rank</u></b>	<b><u>Intermediate Width (mm)</u></b>	<b><u>Common name</u></b>
1		silt
2	<2	sand
3	2 - 64	gravel
4	64 - 256	cobble
5	256 - 1024	small boulder
6	1024 - 4096	large boulder
7		Bedrock



Table 2. Corrected habitat estimates of surface area and corresponding  $\pm$  95% confidence intervals. Yellow Patch Branch is only an estimate because no paired samples were taken. N/A represents confidence intervals that could not be calculated due to low paired sample size,  $n=1$ .

Stream Name	Corrected Surface Area (m <sup>2</sup> )		95% Confidence Interval	
	Pools	Riffles	Pools	Riffles
Kilby Creek	667.3	3,347.1	175.9	N/A
Long Branch	260.7	2,054.2	N/A	N/A
Devils Prong	418.7	1,484.5	89.5	204.4
Little Indian Creek	64.6	1,119.1	N/A	N/A
Yellow Patch Branch	353.2	179.5	N/A	N/A

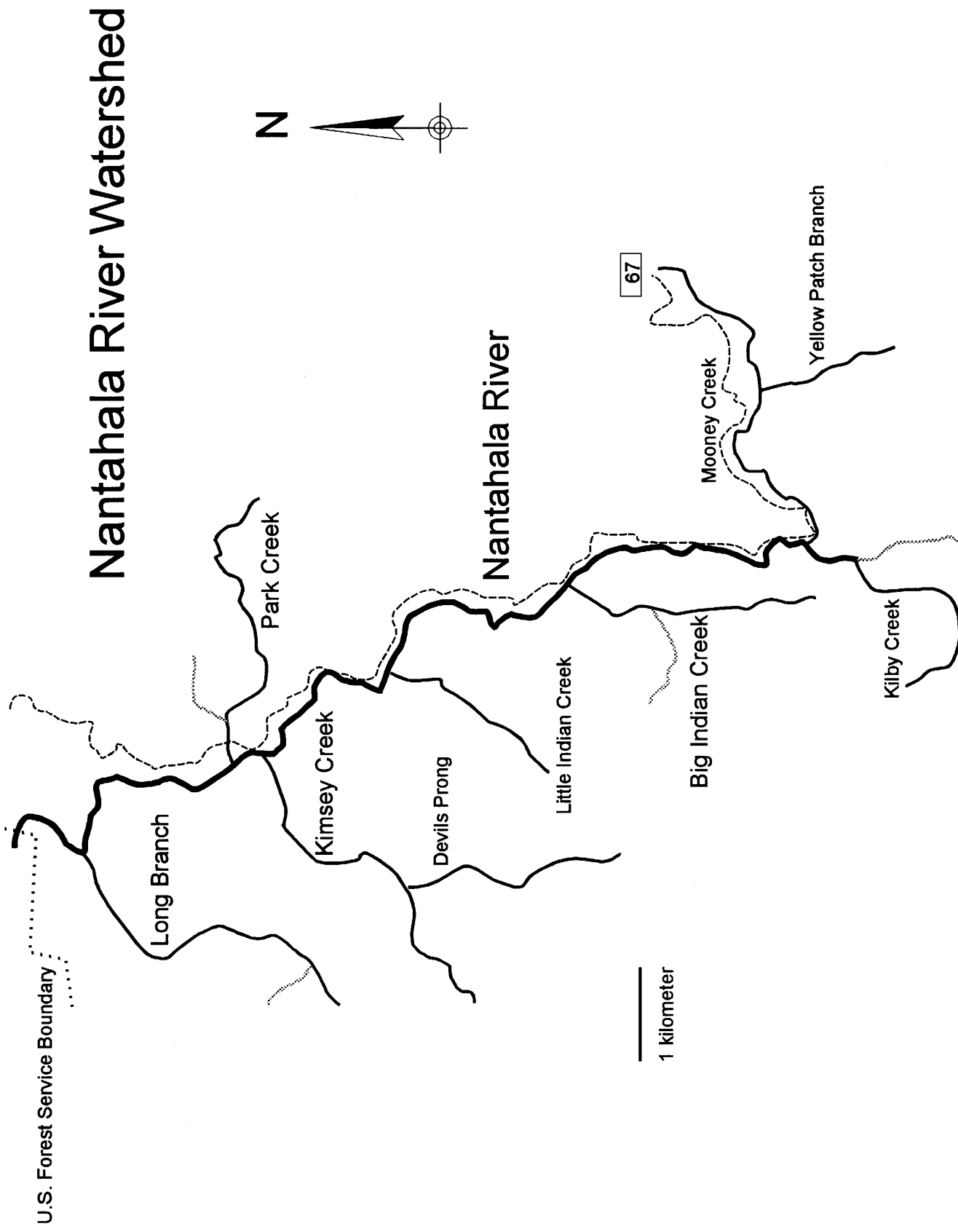


Figure 1. Map showing the Nantahala River Watershed, Nantahala National Forest, North Carolina. Streams surveyed are shown as black solid lines. The dashed line is Forest Service Route 67 and the dotted line is the U.S. Forest Service Boundary. Gray lines are tributaries not surveyed.

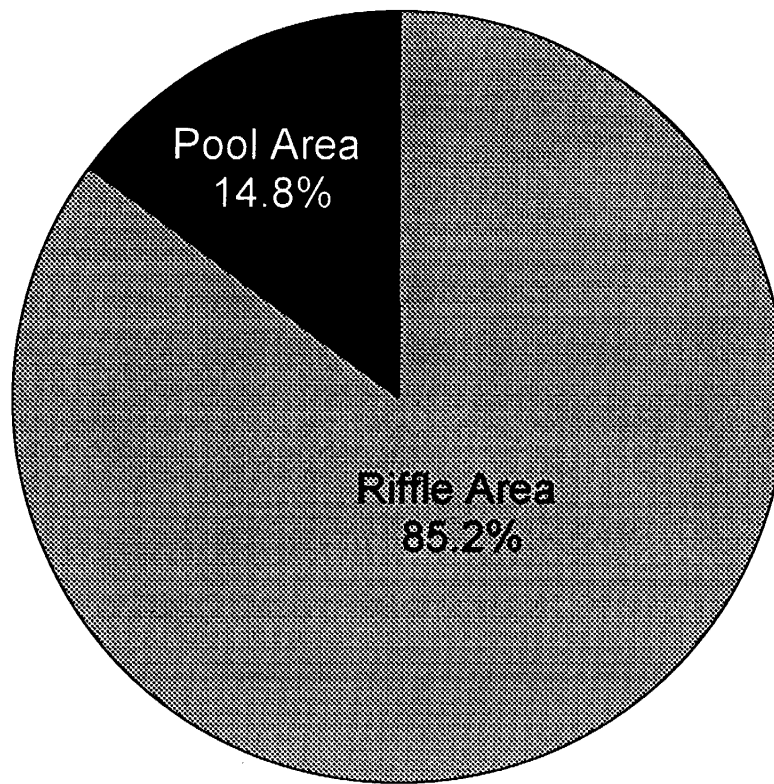


Figure 2. Percent pool and riffle area present in the Nantahala River study section.

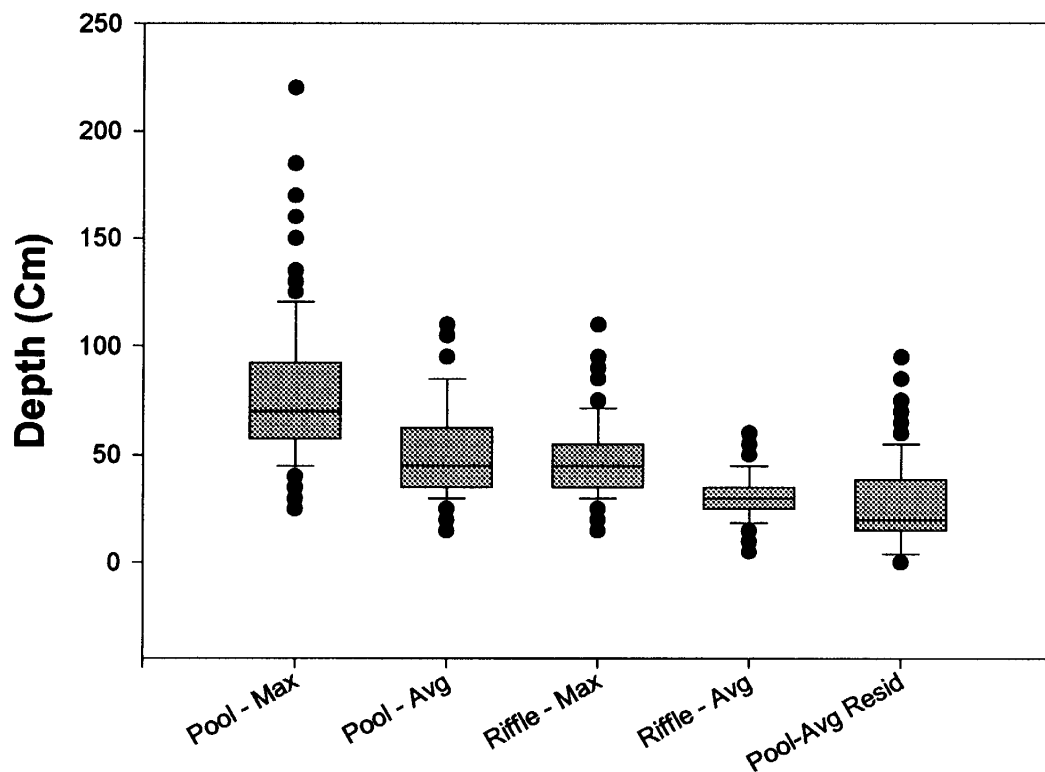


Figure 3. Box plots representing maximum and average depths for pools and riffles, and average residual pool depths for the Nantahala River study section. The boxes enclose the middle 50% of the observations, the bar in the center of the boxes represent the median, and the capped lines extending above and below the boxes represent the 90% and 10% quantiles.

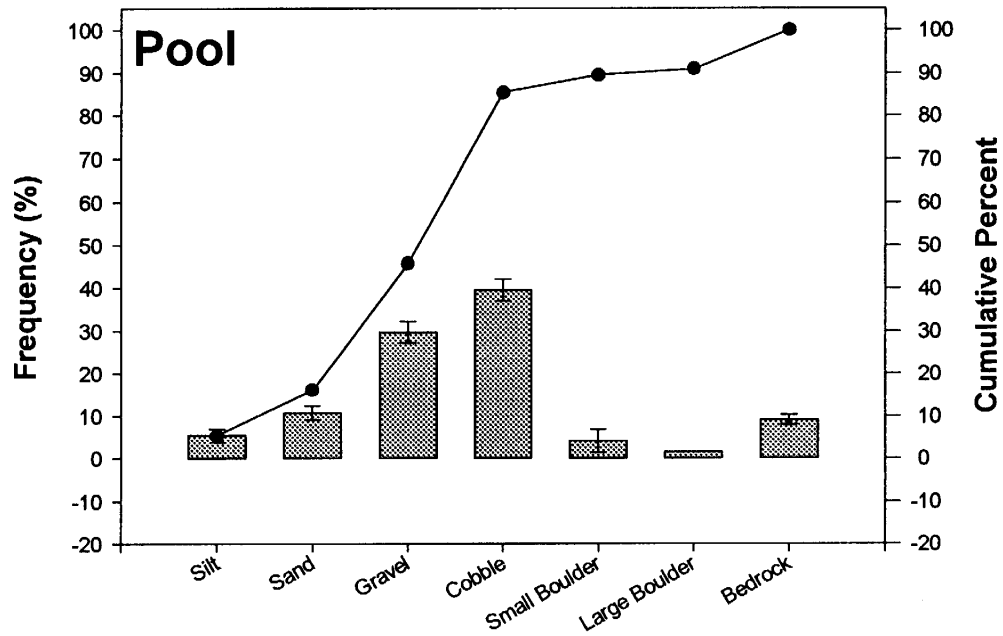


Figure 4. Average corrected estimates of substrate in pools for the Nantahala River study section.

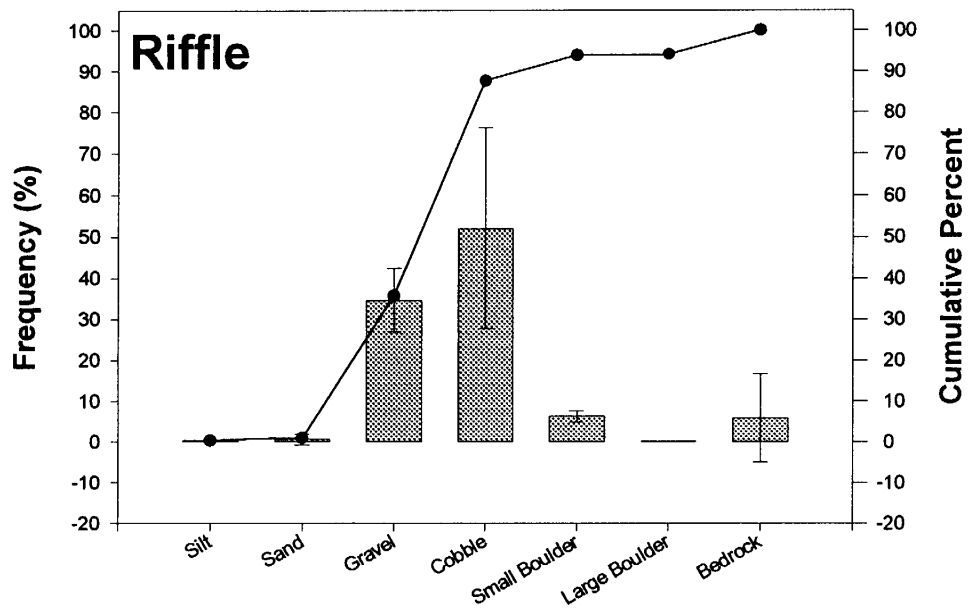


Figure 5. Average corrected estimates of substrate in riffles for the Nantahala River study section.

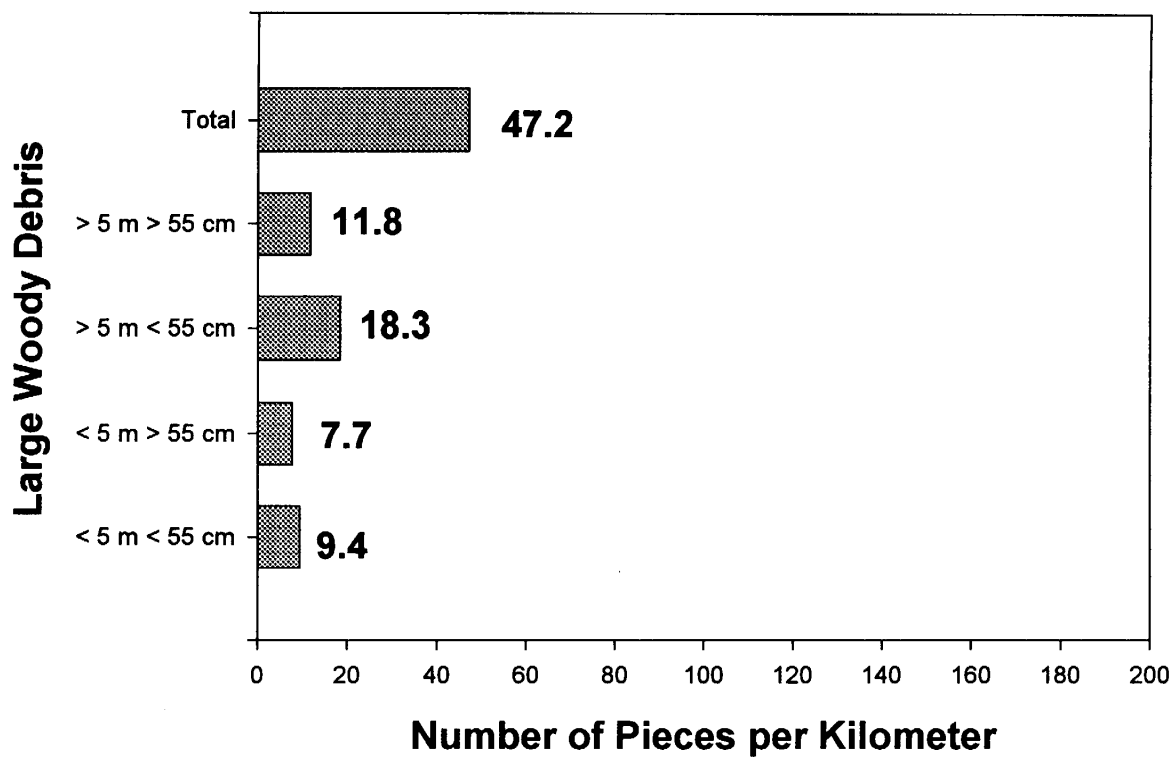


Figure 6. Pieces of large woody debris per kilometer in the Nantahala River study section.

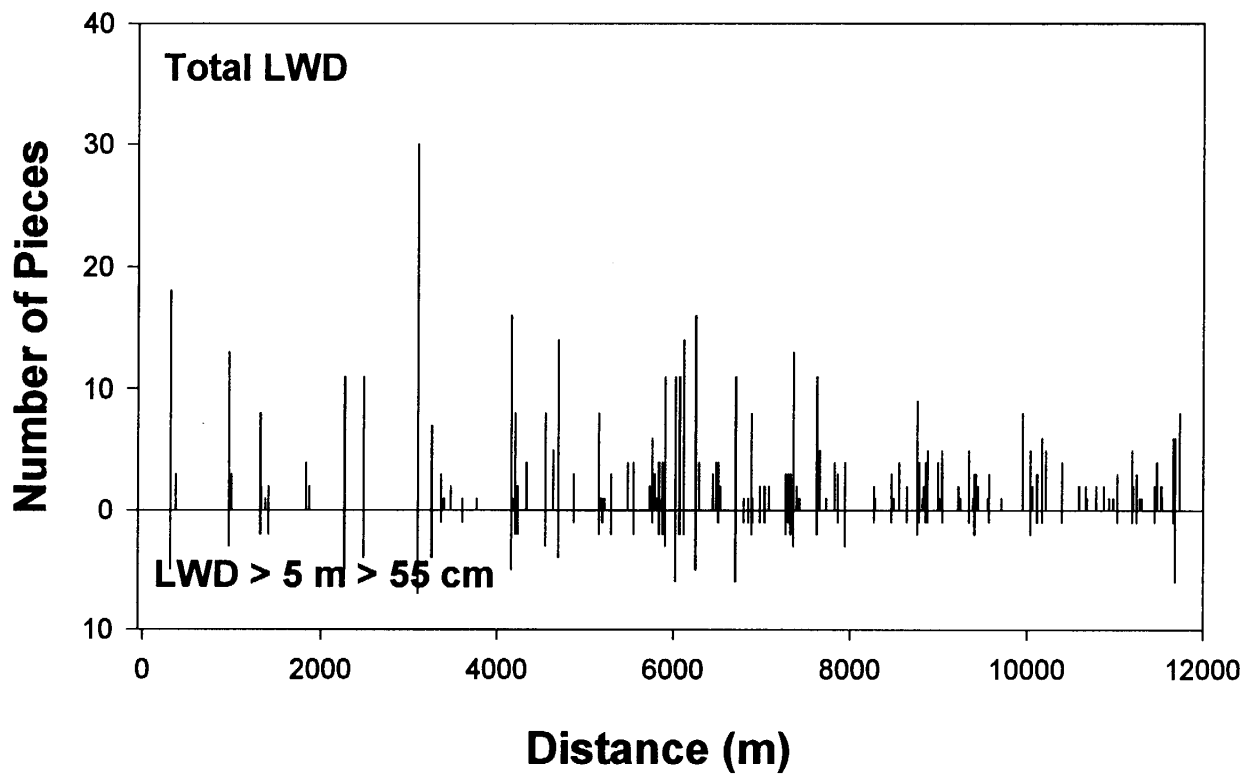


Figure 7. Distribution and total abundance of large woody debris in the Nantahala River study section.

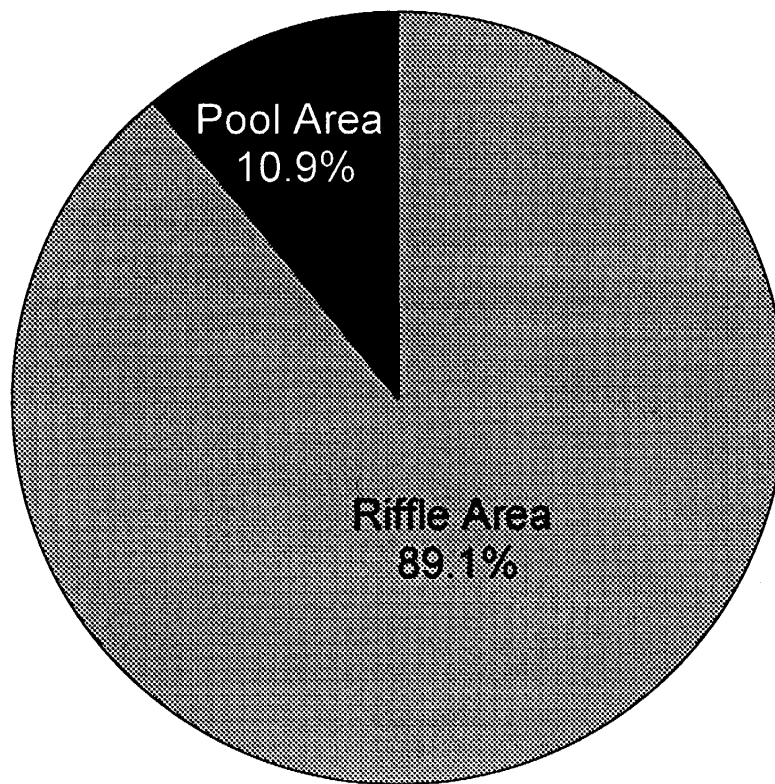


Figure 8. Percent pool and riffle area present in the Kimsey Creek study section.

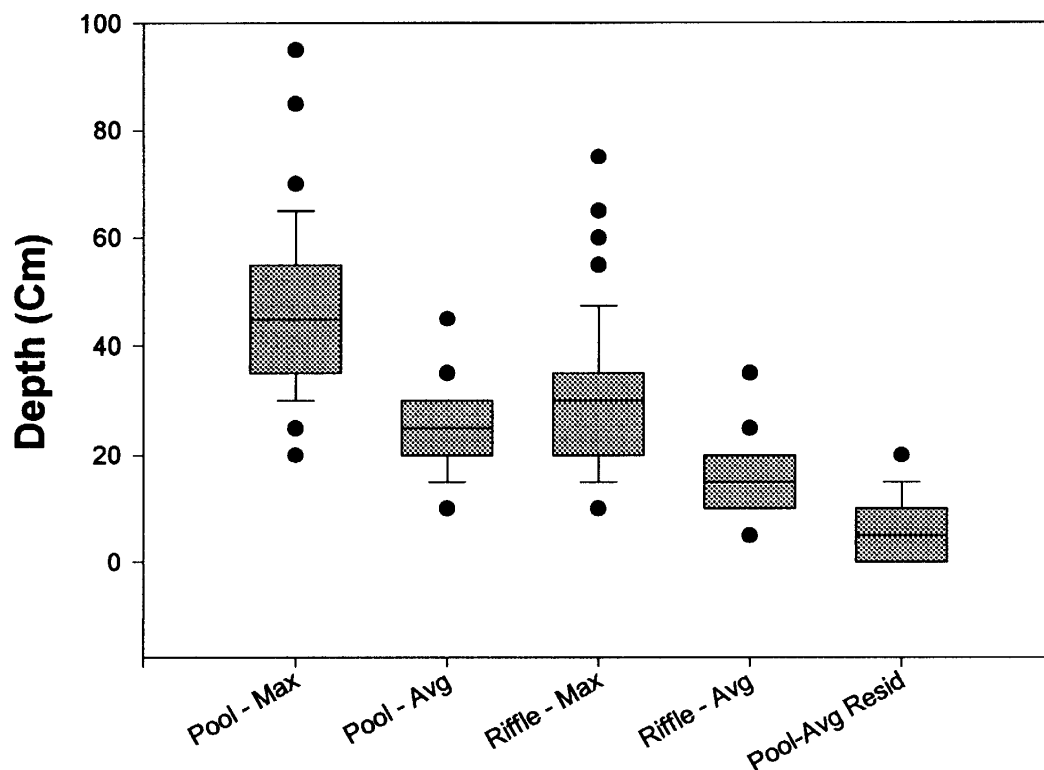


Figure 9. Box plots representing maximum and average depths for pools and riffles, and average residual pool depths for the Kimsey Creek study section. The boxes enclose the middle 50% of the observations, the bar in the center of the boxes represent the median, and the capped lines extending above and below the boxes represent the 90% and 10% quantiles.

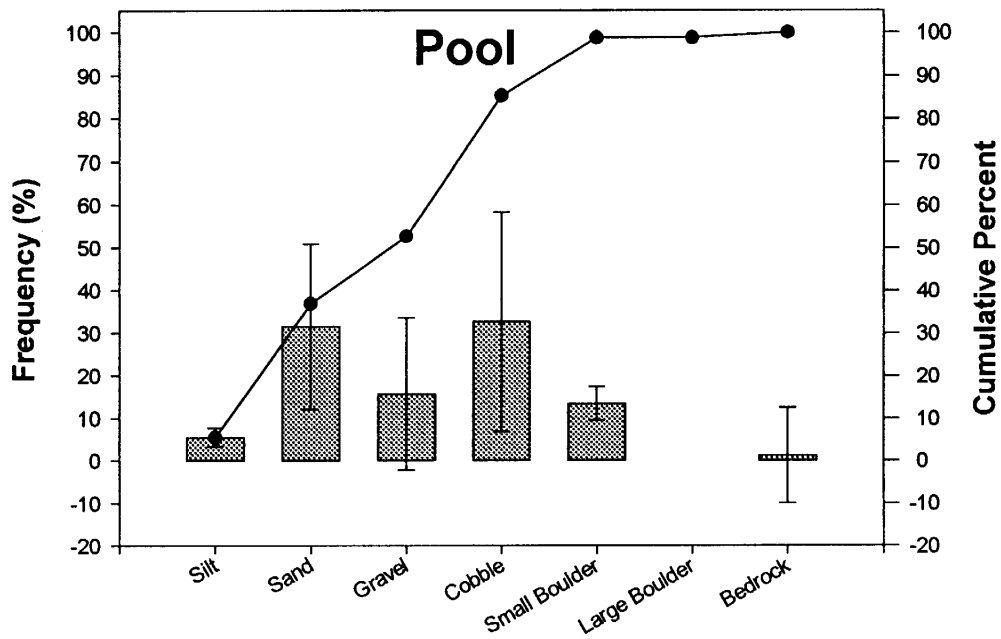


Figure 10. Average corrected estimates of substrate in pools for the Kimsey Creek study section.

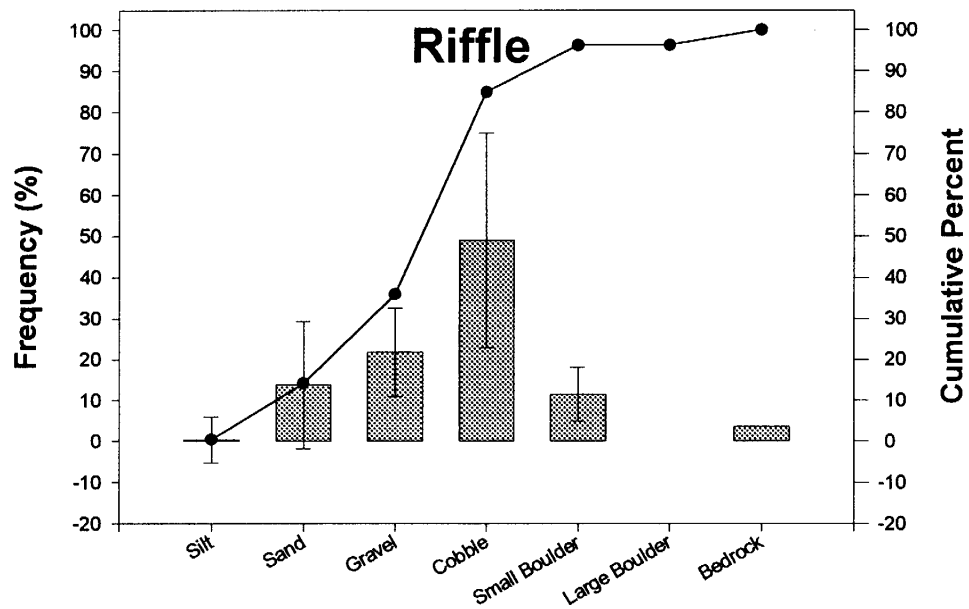


Figure 11. Average corrected estimates of substrate in riffles for the Kimsey Creek study section.

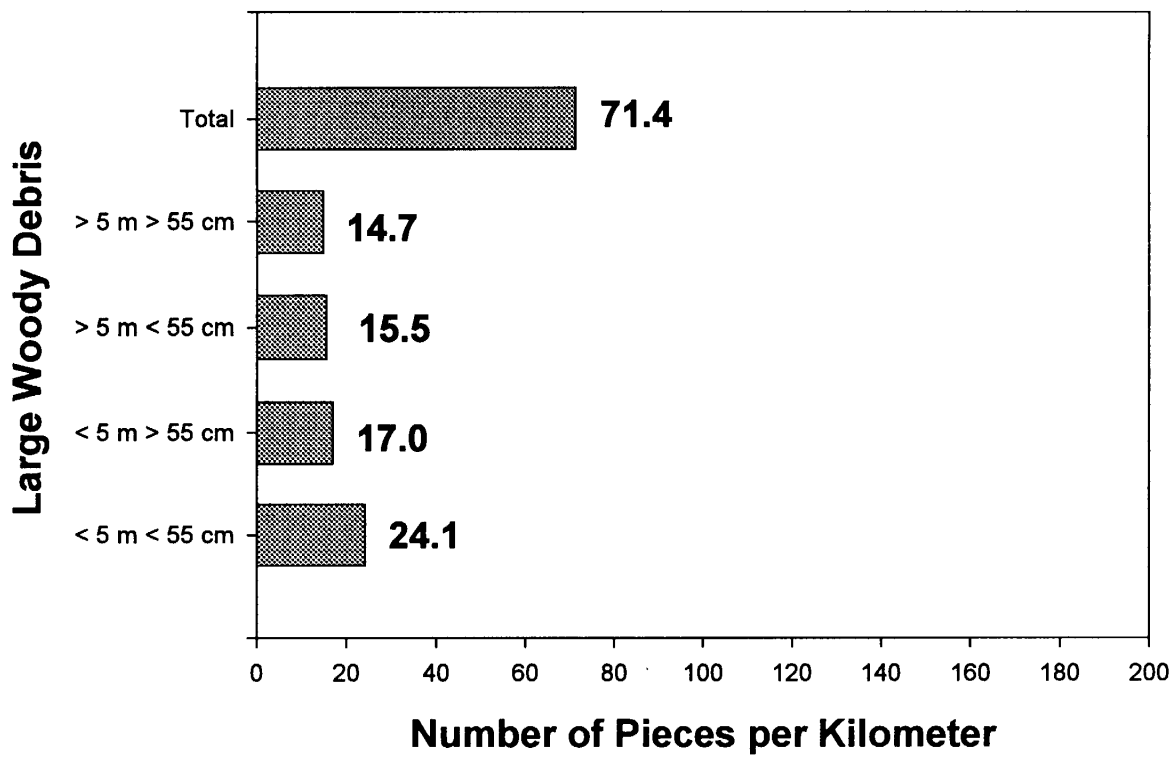


Figure 12. Pieces of large woody debris per kilometer in the Kimsey Creek study section.

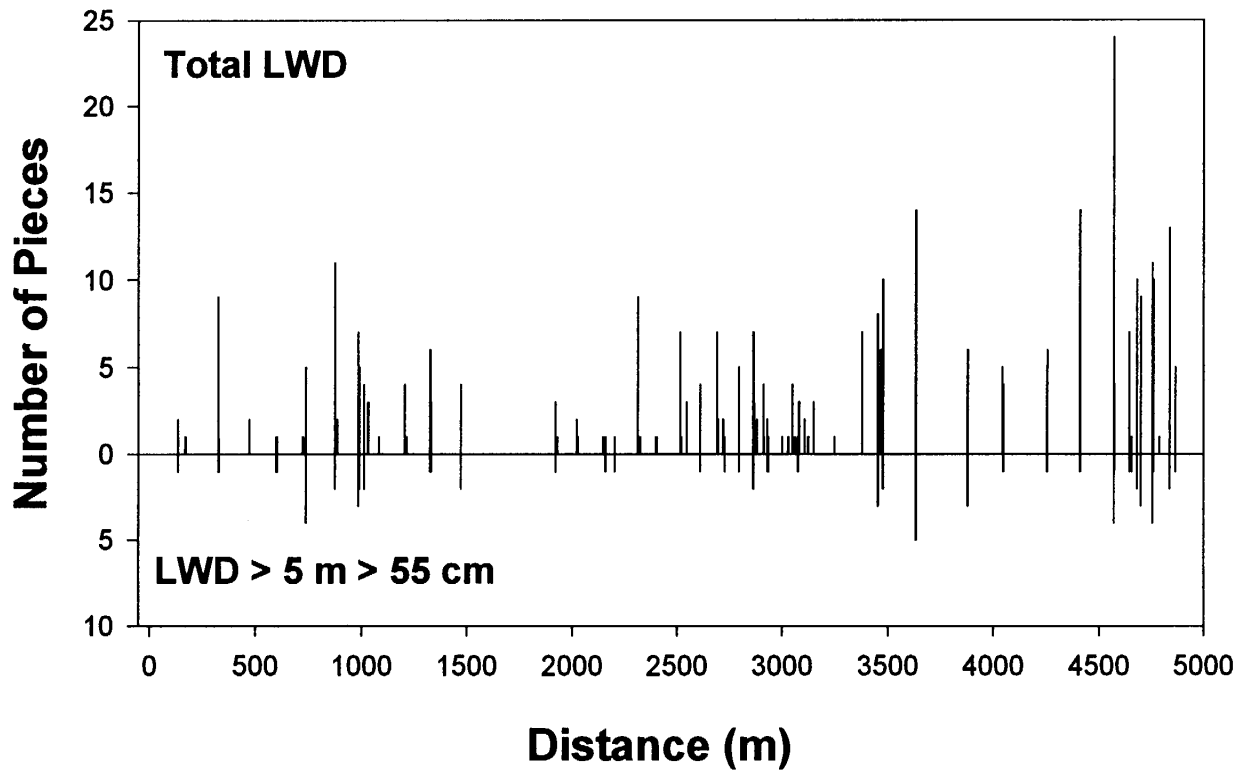


Figure 13. Distribution and total abundance of large woody debris in the Kimsey Creek study section.



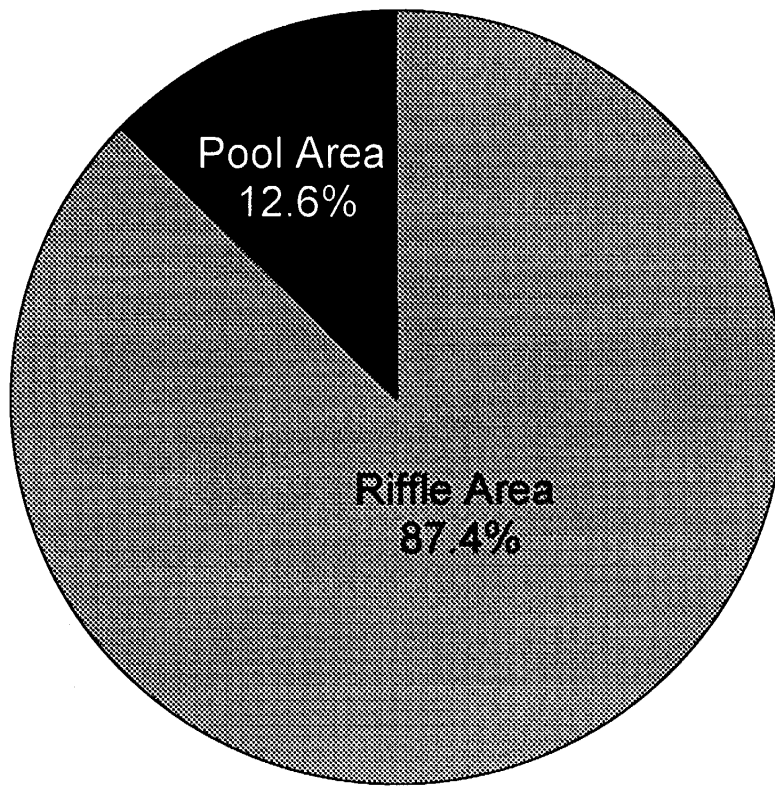


Figure 14. Percent pool and riffle area present in the Park Creek study section.

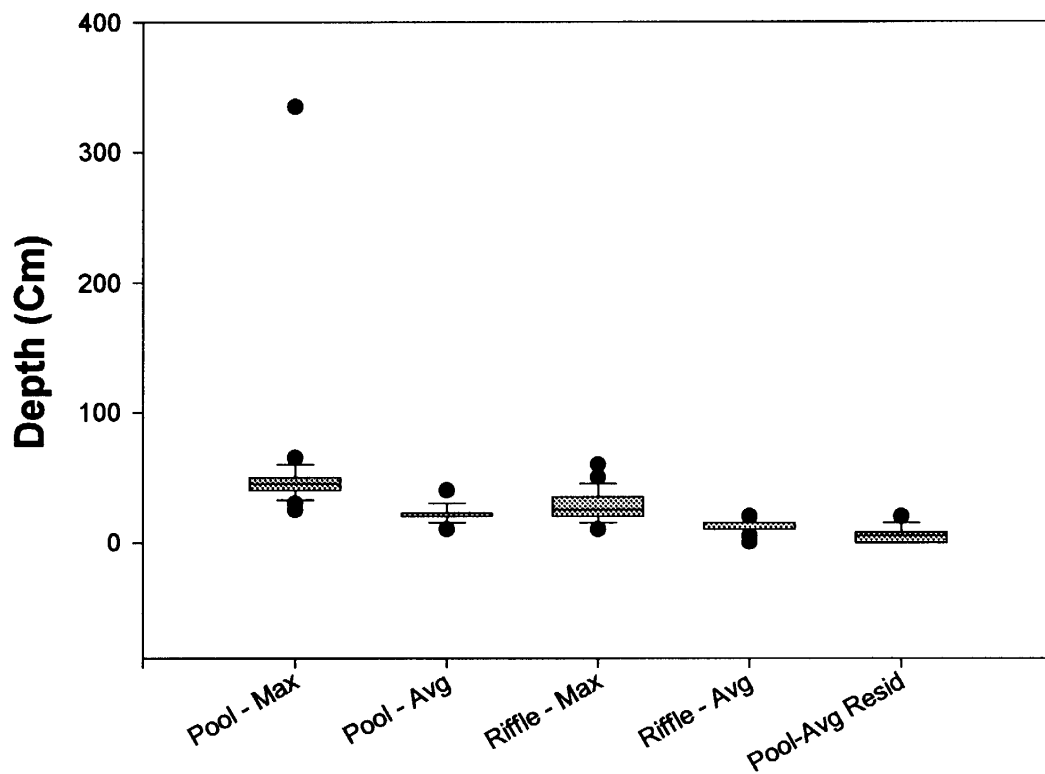


Figure 15. Box plots representing maximum and average depths for pools and riffles, and average residual pool depths for the Park Creek study section. The boxes enclose the middle 50% of the observations, the bar in the center of the boxes represent the median, and the capped lines extending above and below the boxes represent the 90% and 10% quantiles.

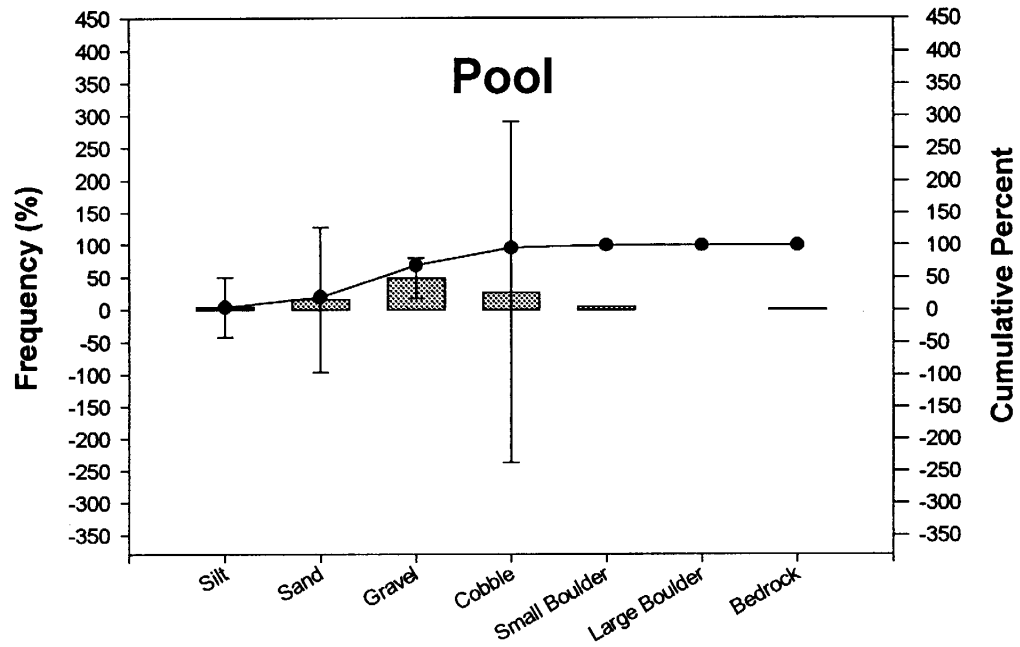


Figure 16. Average corrected estimates of substrate in pools for the Park Creek study section.

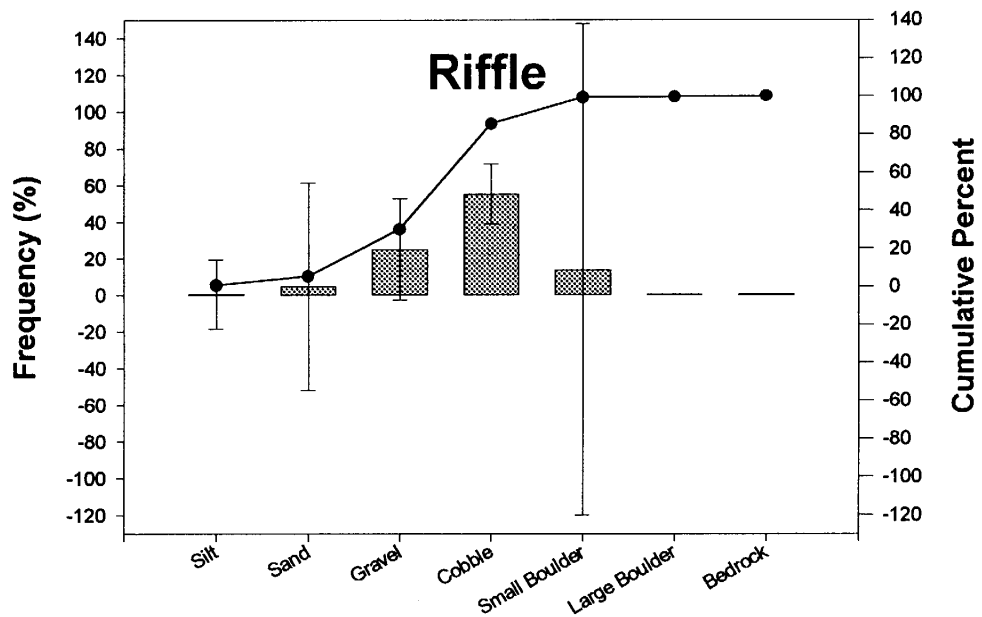


Figure 17. Average corrected estimates of substrate in riffles for the Park Creek study section.

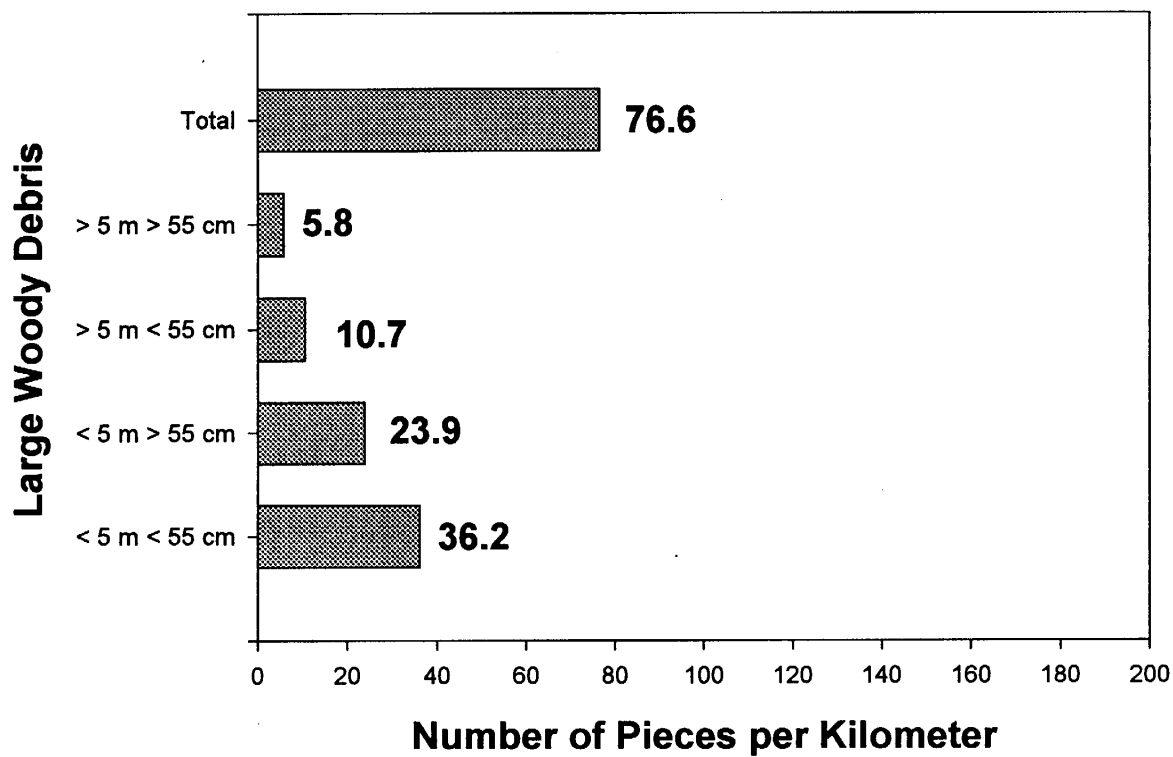


Figure 18. Pieces of large woody debris per kilometer in the Park Creek study section.

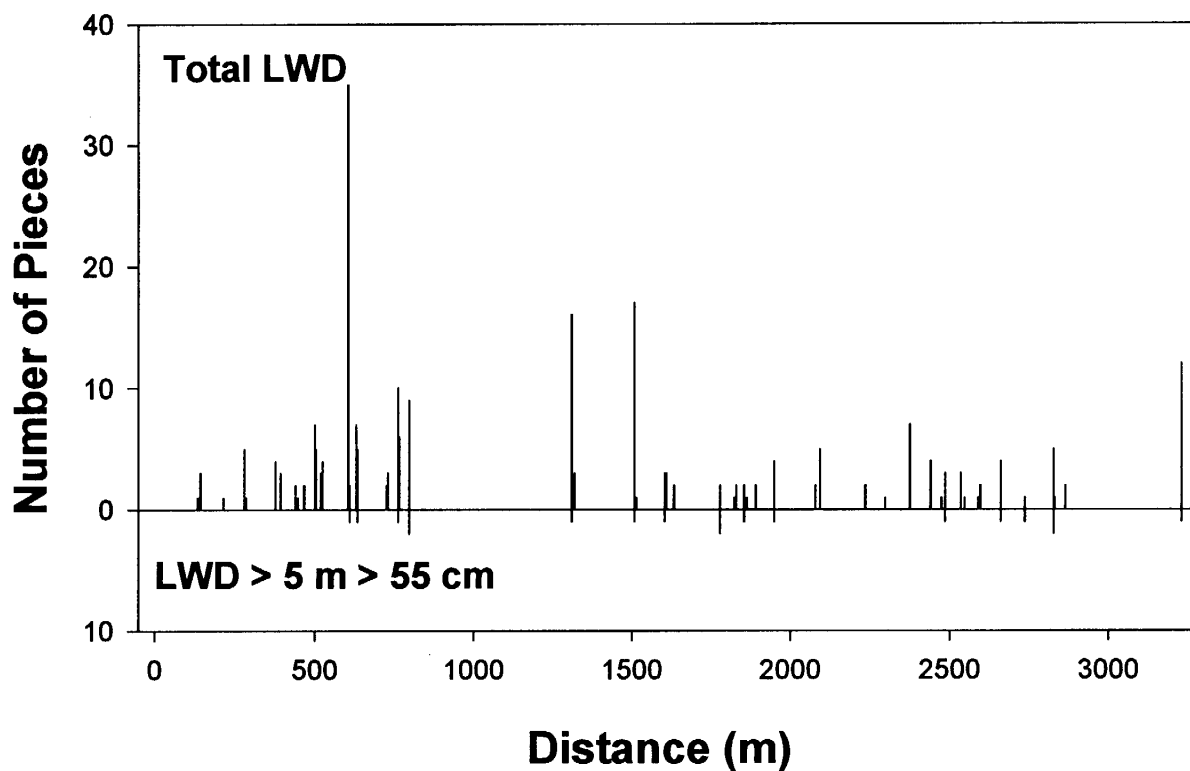


Figure 19. Distribution and total abundance of large woody debris in the Park Creek study section.

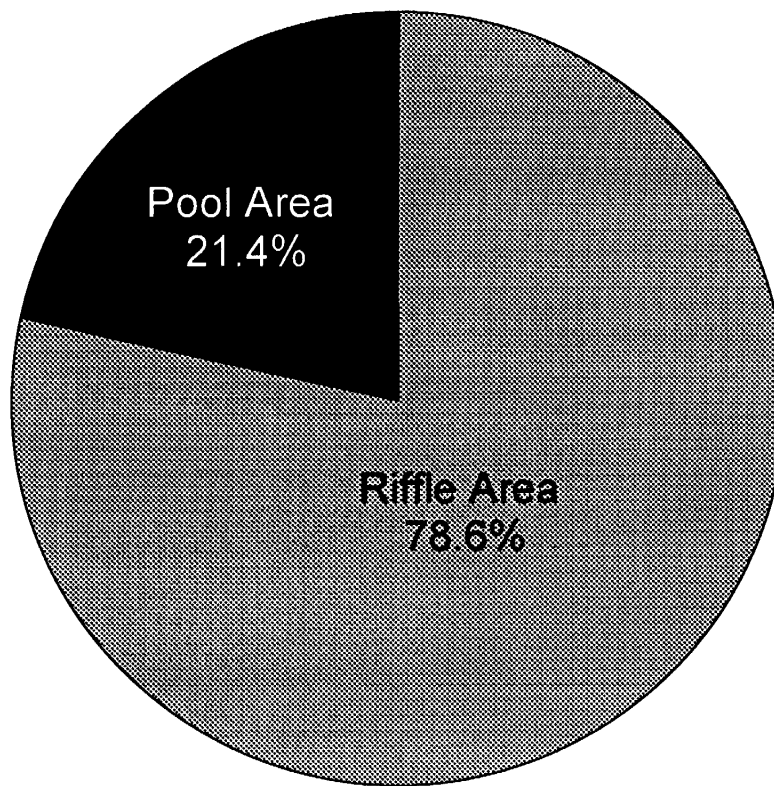


Figure 20. Percent pool and riffle area present in the Mooney Creek study section.

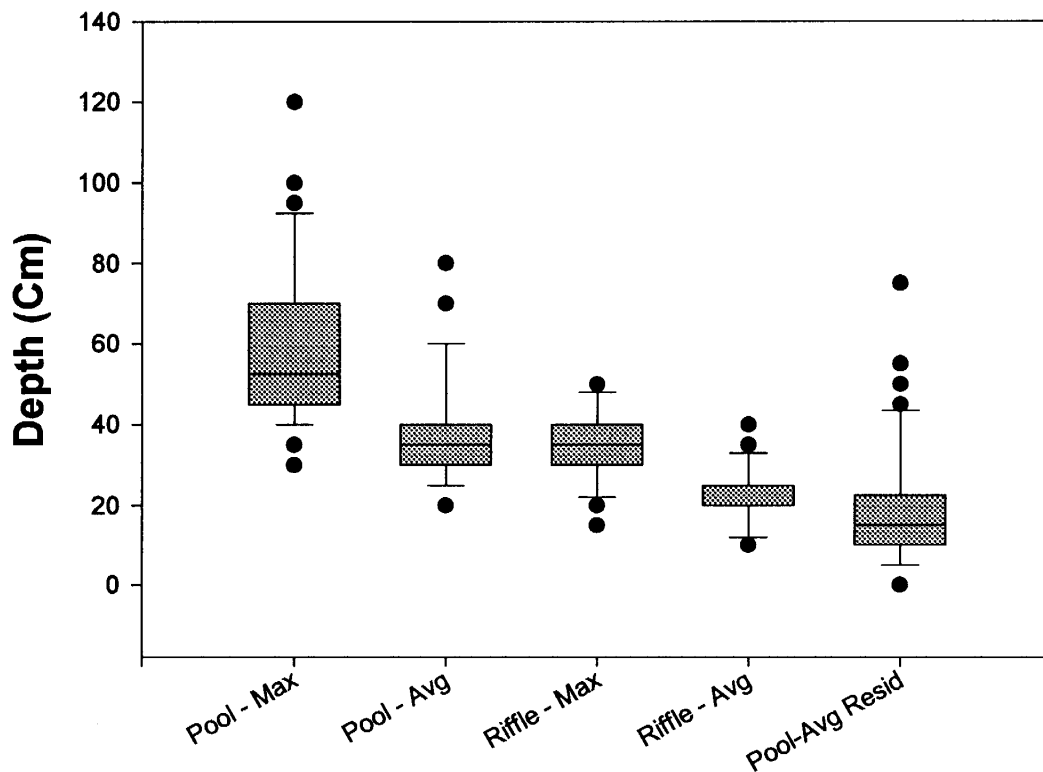


Figure 21. Box plots representing maximum and average depths for pools and riffles, and average residual pool depths for the Mooney Creek study section. The boxes enclose the middle 50% of the observations, the bar in the center of the boxes represent the median, and the capped lines extending above and below the boxes represent the 90% and 10% quantiles.

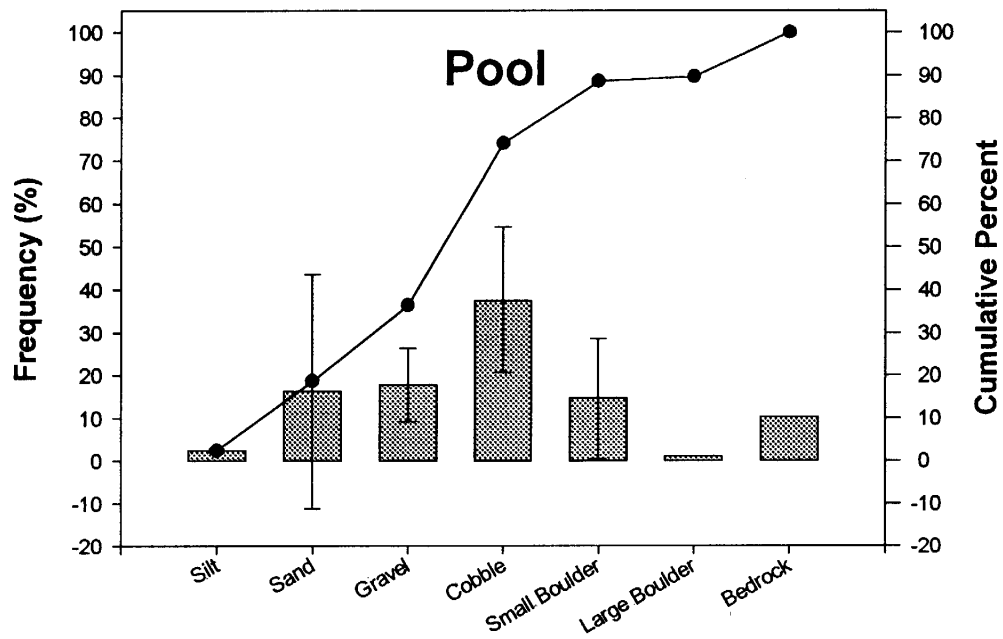


Figure 22. Average corrected estimates of substrate in pools for the Mooney Creek study section.

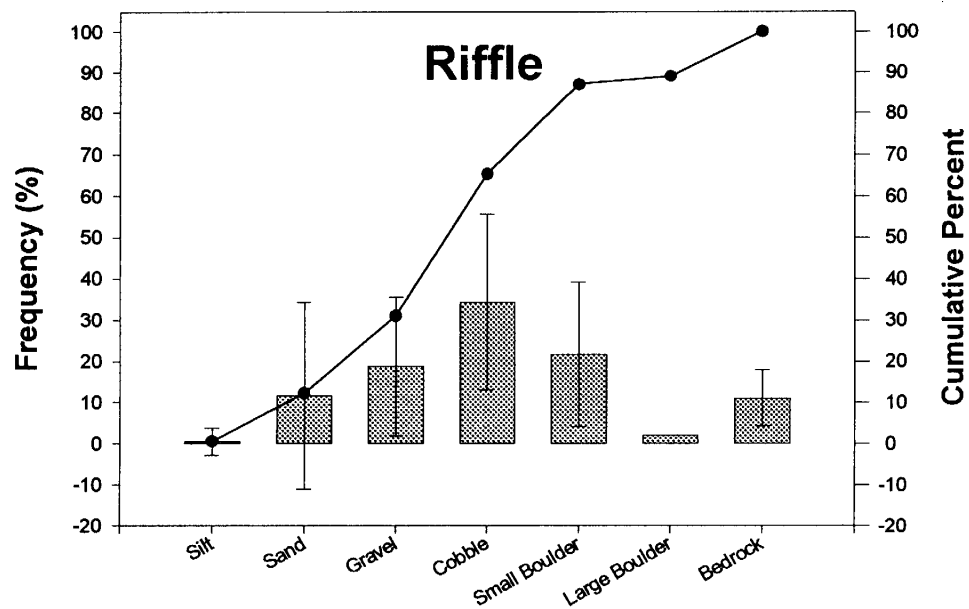


Figure 23. Average corrected estimates of substrate in riffles for the Mooney Creek study section.

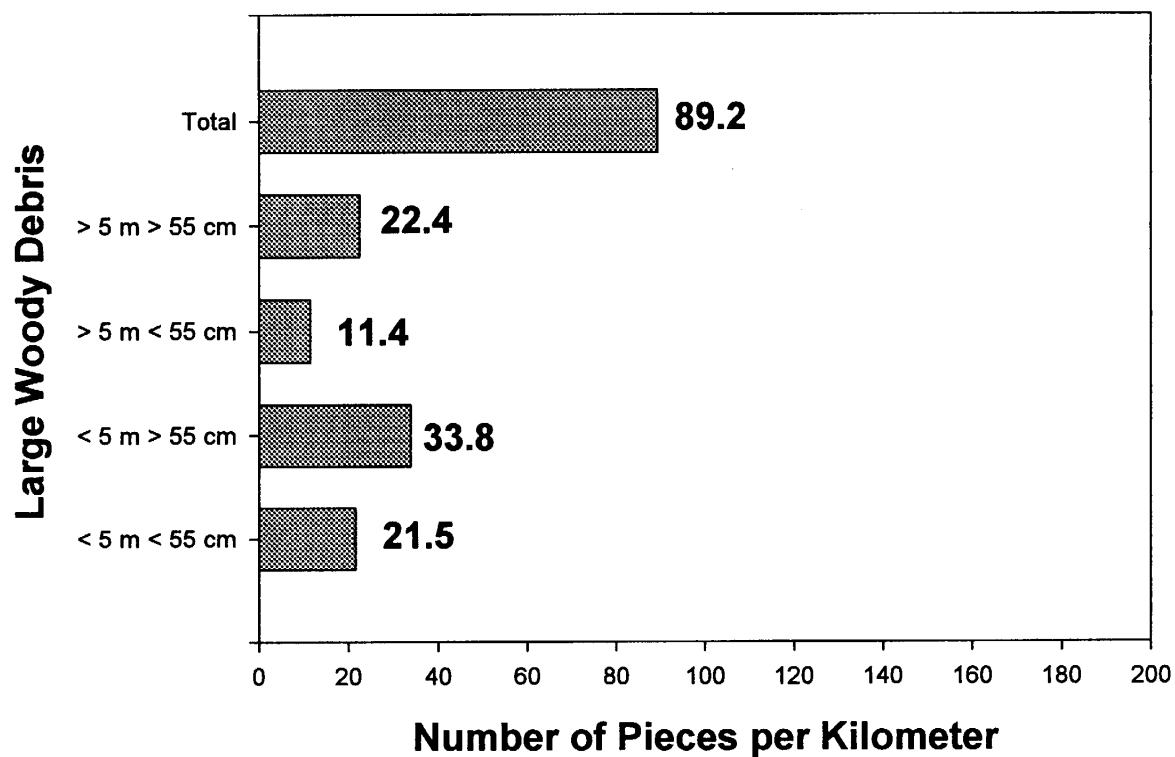


Figure 24. Pieces of large woody debris per kilometer in the Mooney Creek study section.

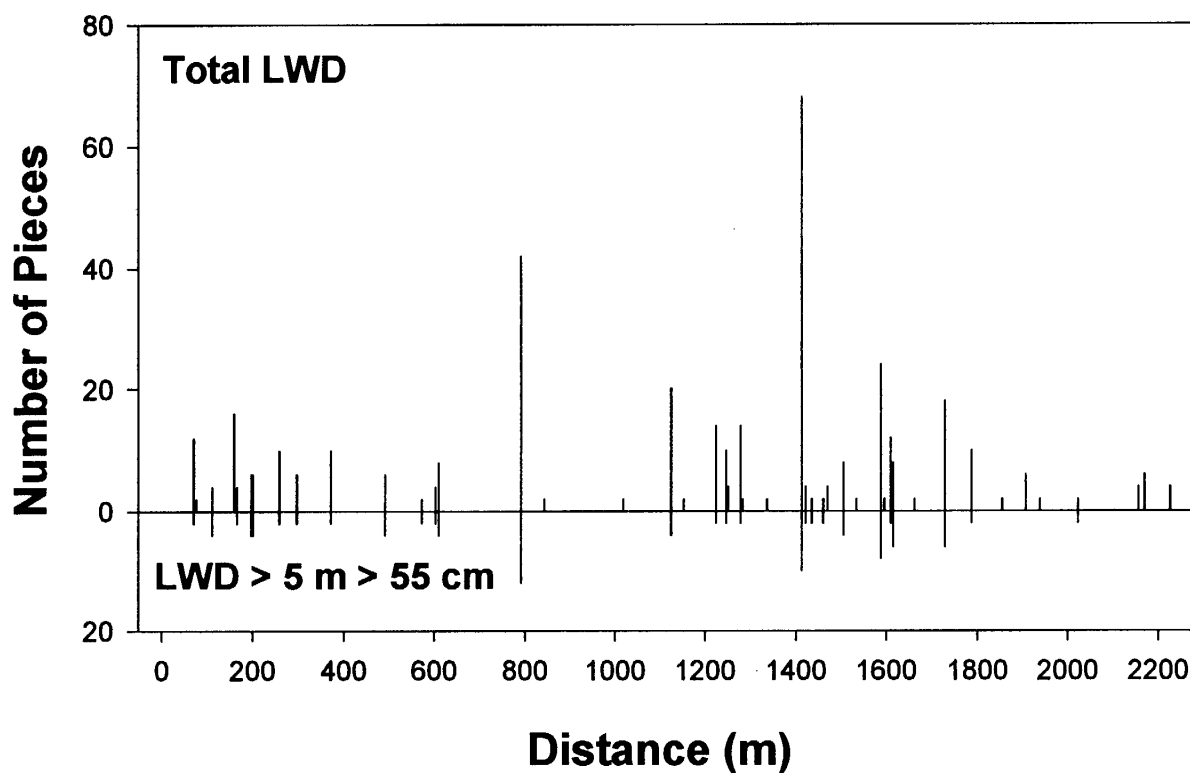


Figure 25. Distribution and total abundance of large woody debris in the Mooney Creek study section.

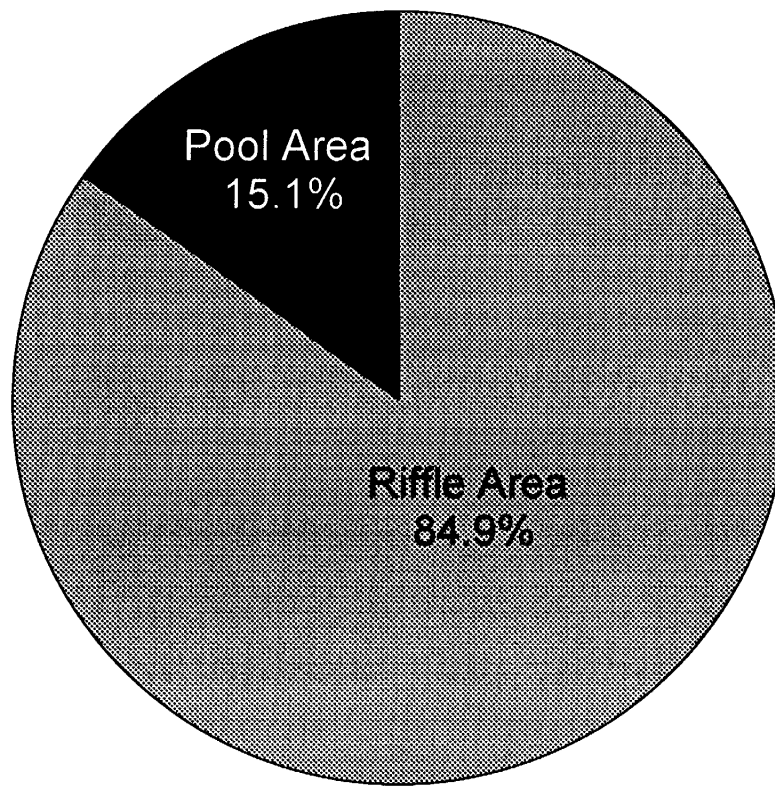


Figure 26. Percent pool and riffle area present in the Big Indian Creek study section.

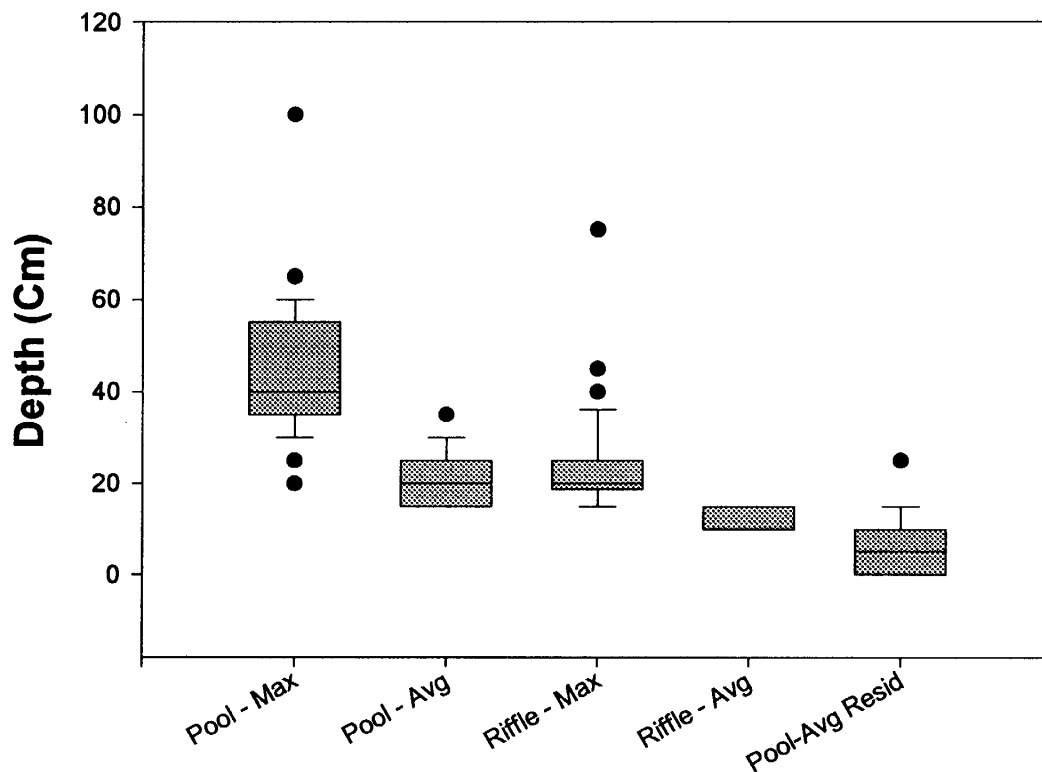


Figure 27. Box plots representing maximum and average depths for pools and riffles, and average residual pool depths for the Big Indian Creek study section. The boxes enclose the middle 50% of the observations, the bar in the center of the boxes represent the median, and the capped lines extending above and below the boxes represent the 90% and 10% quantiles.

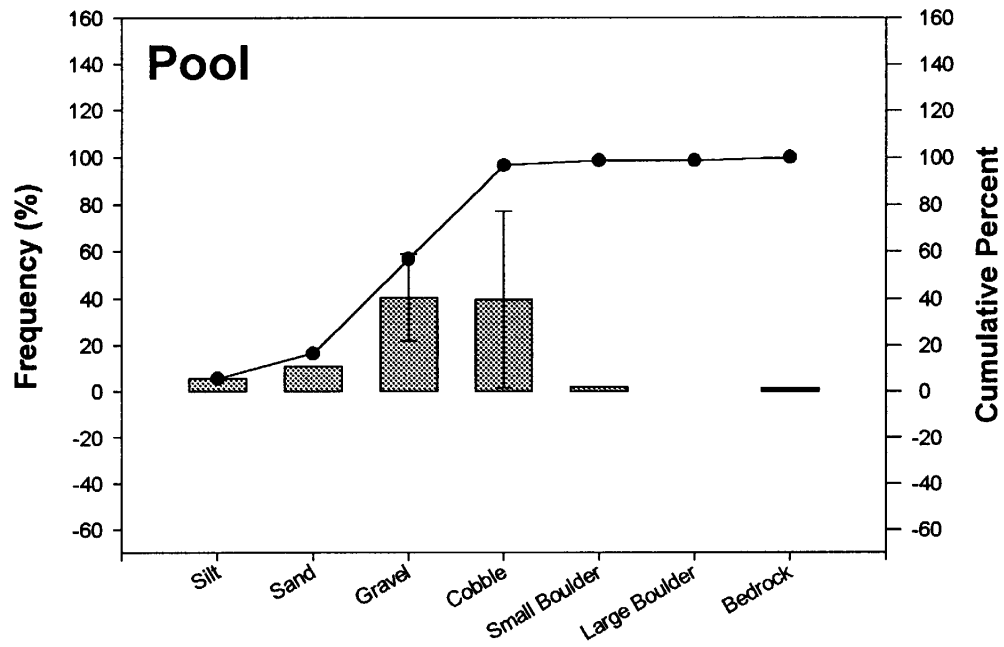


Figure 28. Average corrected estimates of substrate in pools for the Big Indian Creek study section.

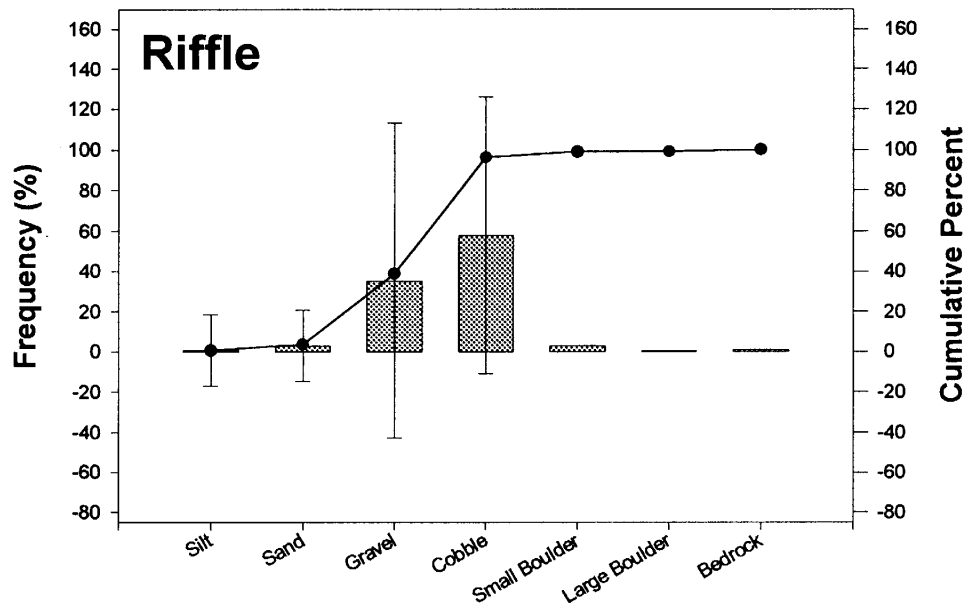


Figure 29. Average corrected estimates of substrate in riffles for the Big Indian Creek study section.



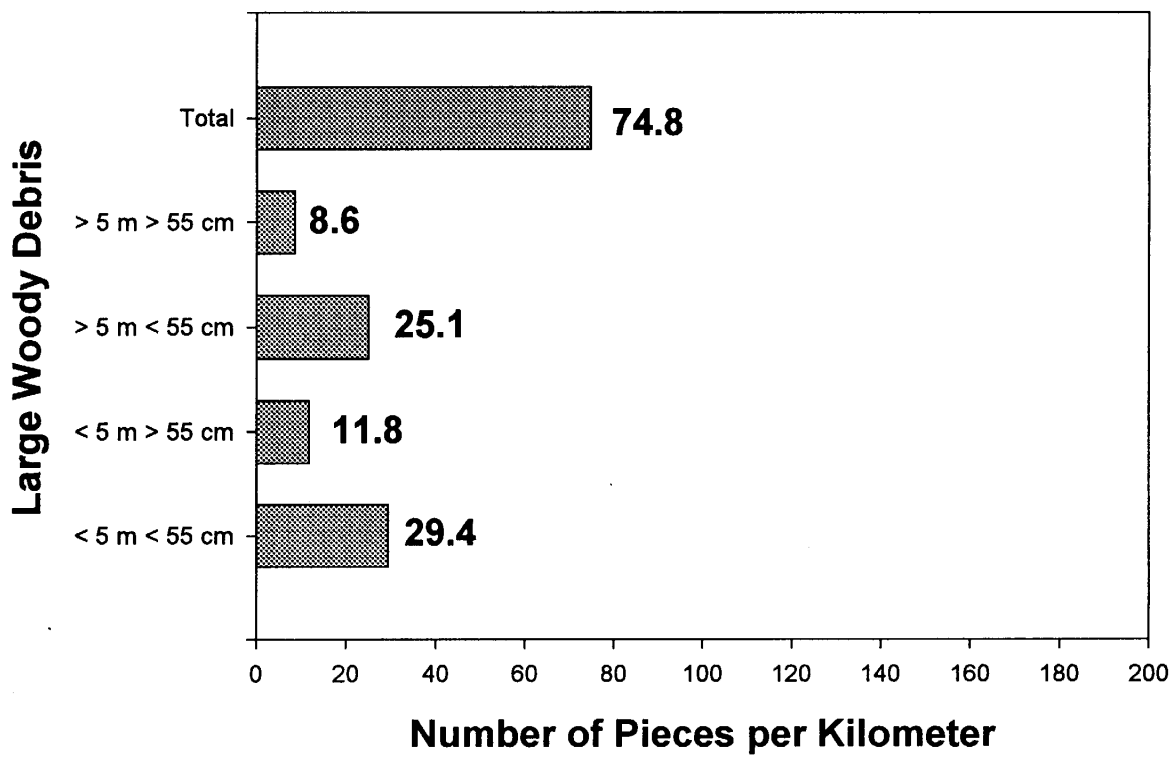


Figure 30. Pieces of large woody debris per kilometer in the Big Indian Creek study section.

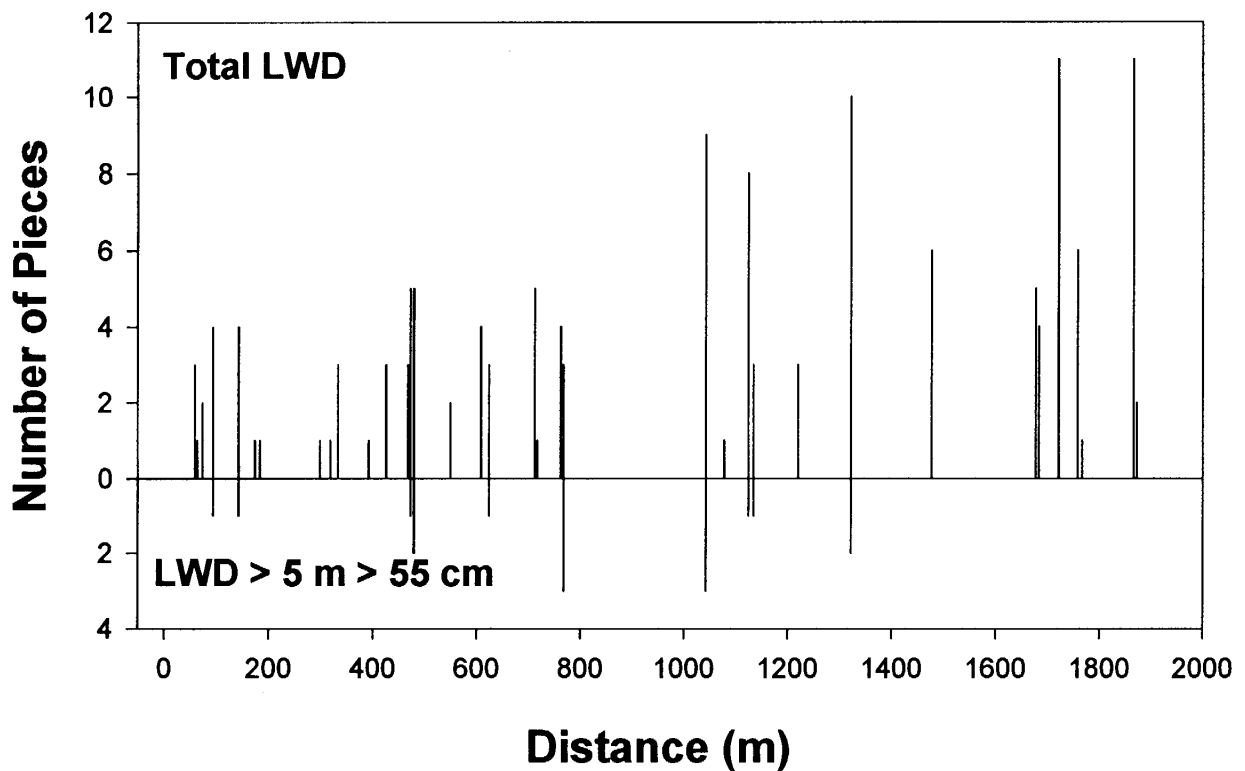


Figure 31. Distribution and total abundance of large woody debris in the Big Indian Creek study section.

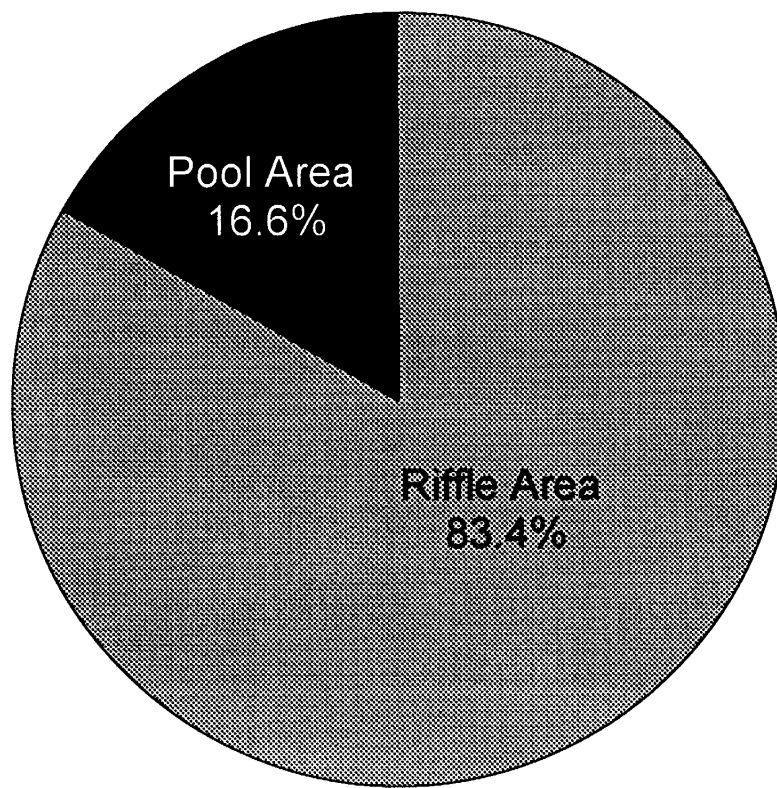


Figure 32. Percent pool and riffle area present in the Kilby Creek study section.

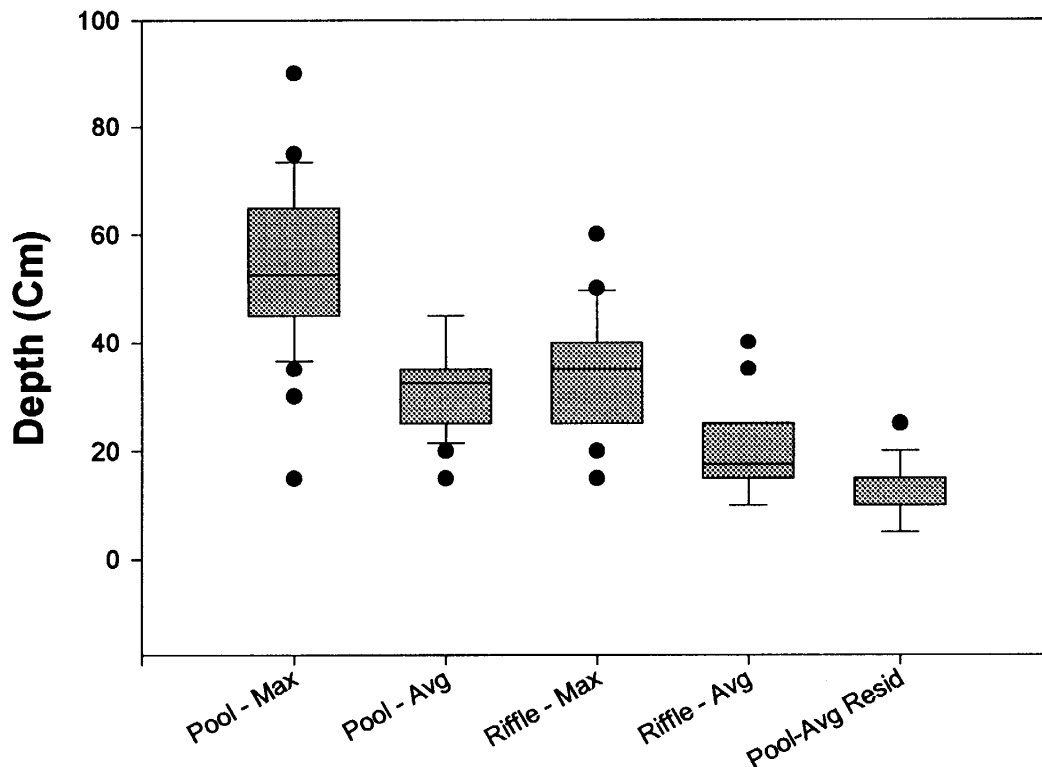


Figure 33. Box plots representing maximum and average depths for pools and riffles, and average residual pool depths for the Kilby Creek study section. The boxes enclose the middle 50% of the observations, the bar in the center of the boxes represent the median, and the capped lines extending above and below the boxes represent the 90% and 10% quantiles.

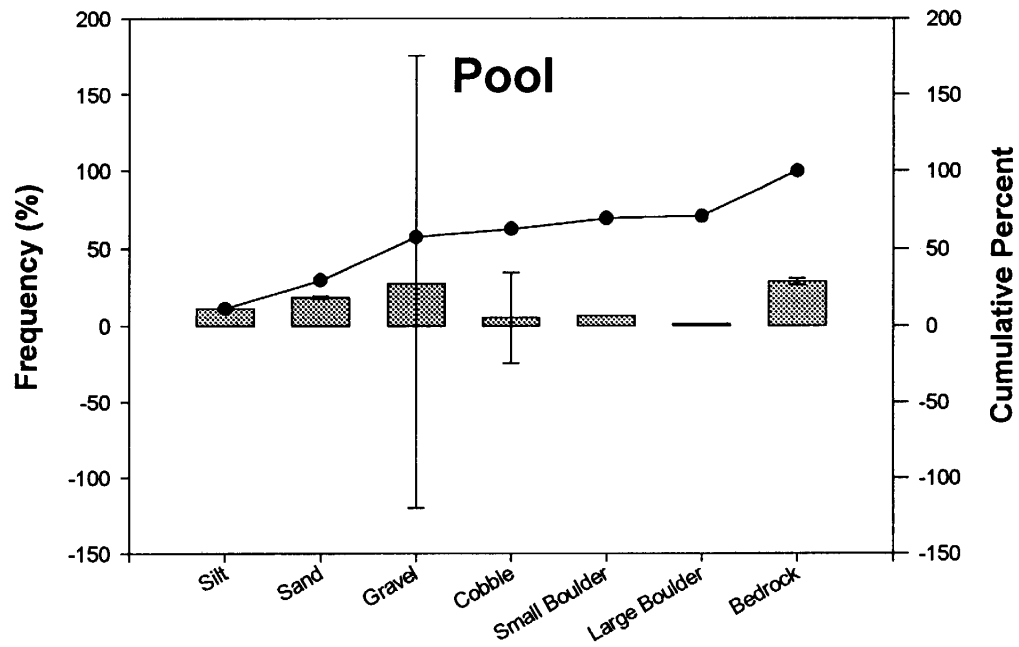


Figure 34. Average corrected estimates of substrate in pools for the Kilby Creek study section.

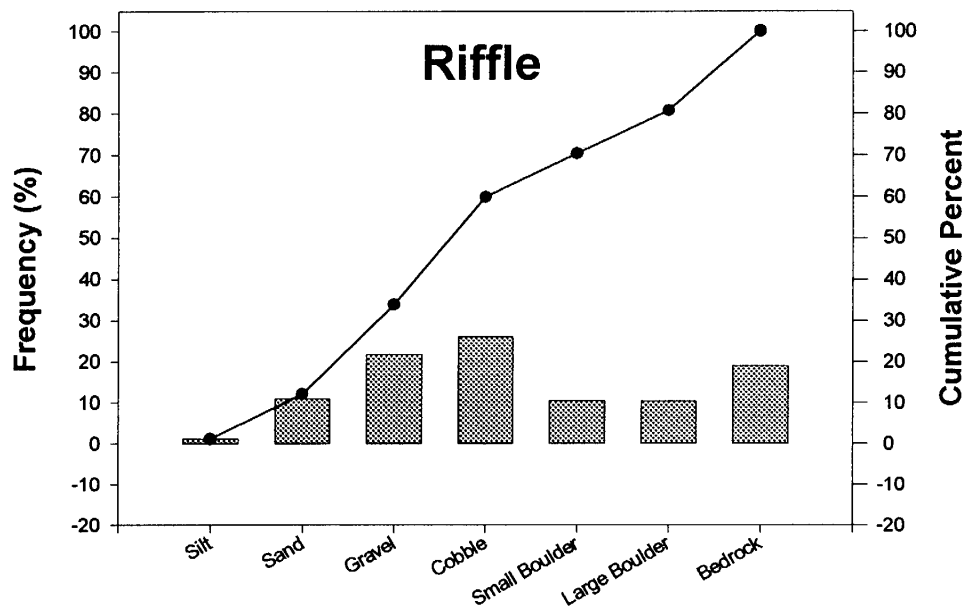


Figure 35. Average corrected estimates of substrate in riffles for the Kilby Creek study section. No confidence intervals were calculated due to only 1 paired sample.

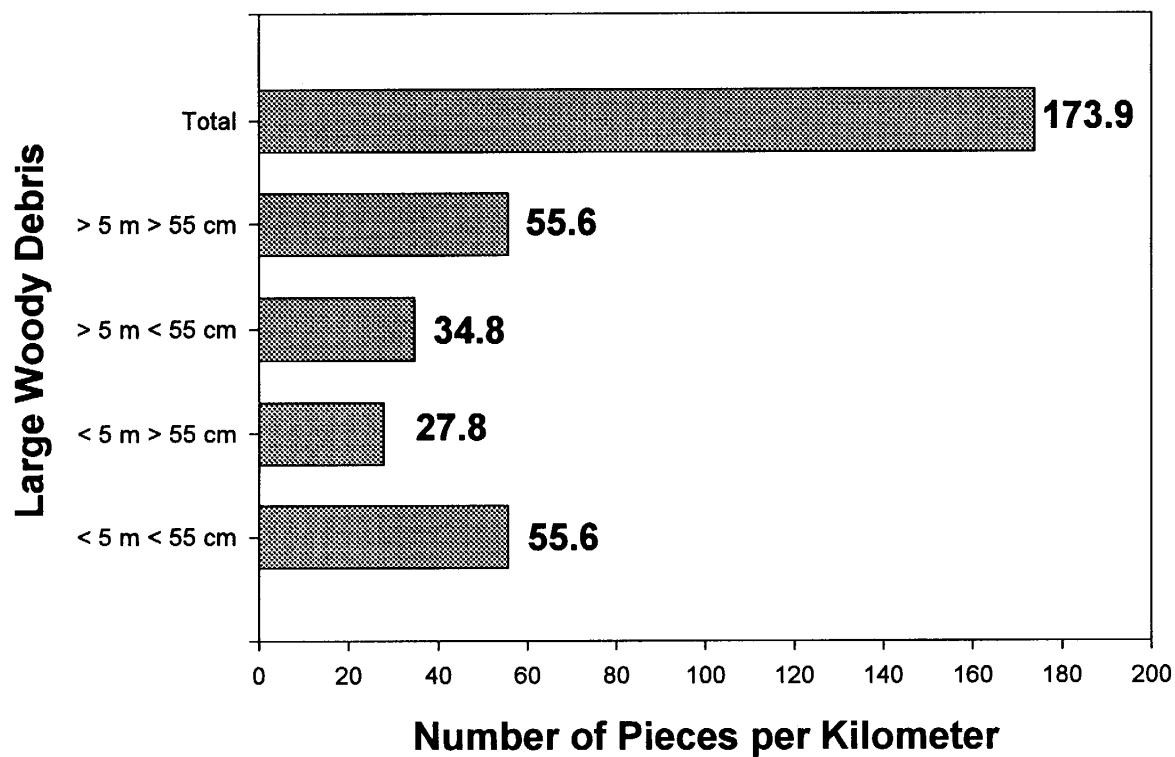


Figure 36. Pieces of large woody debris per kilometer in the Kilby Creek study section.

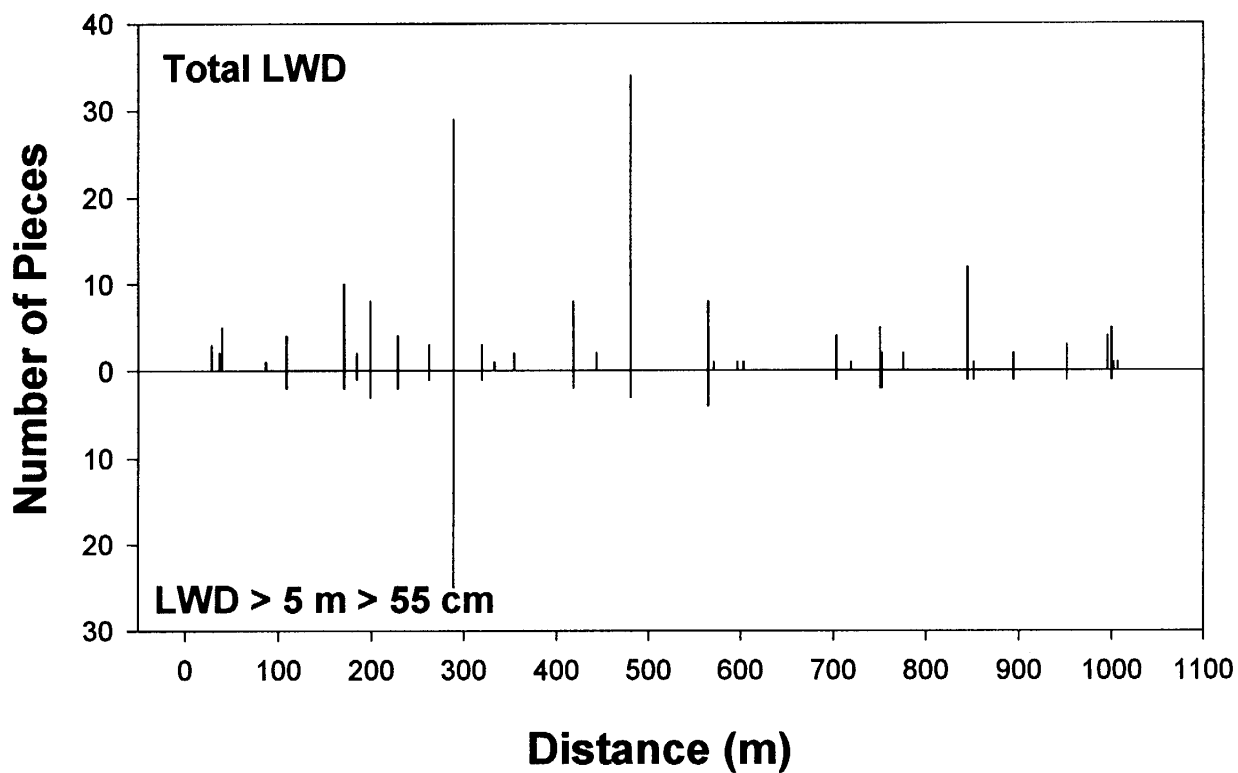


Figure 37. Distribution and total abundance of large woody debris in the Kilby Creek study section.

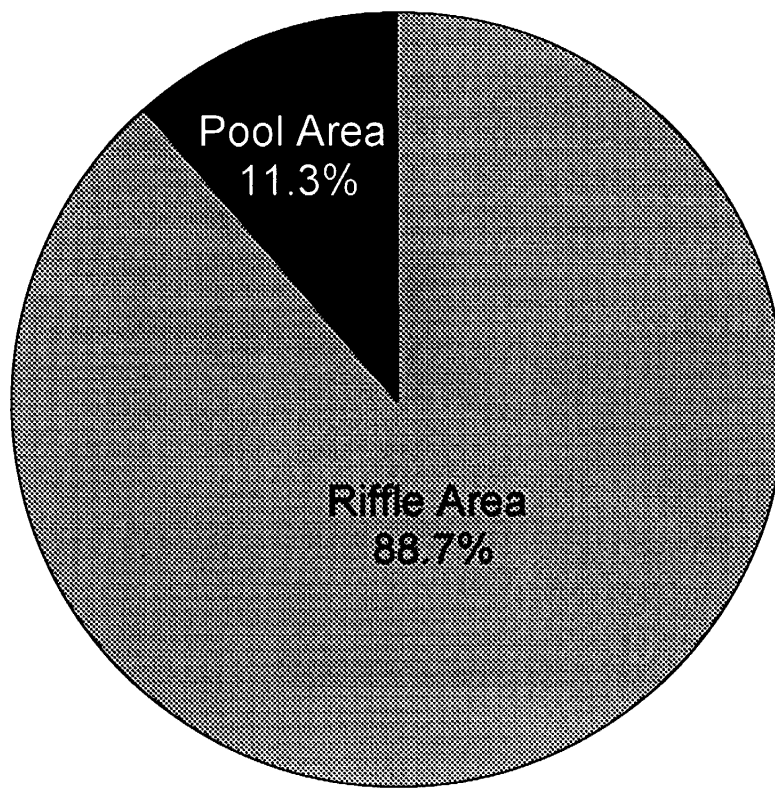


Figure 38. Percent pool and riffle area present in the Long Branch study section.

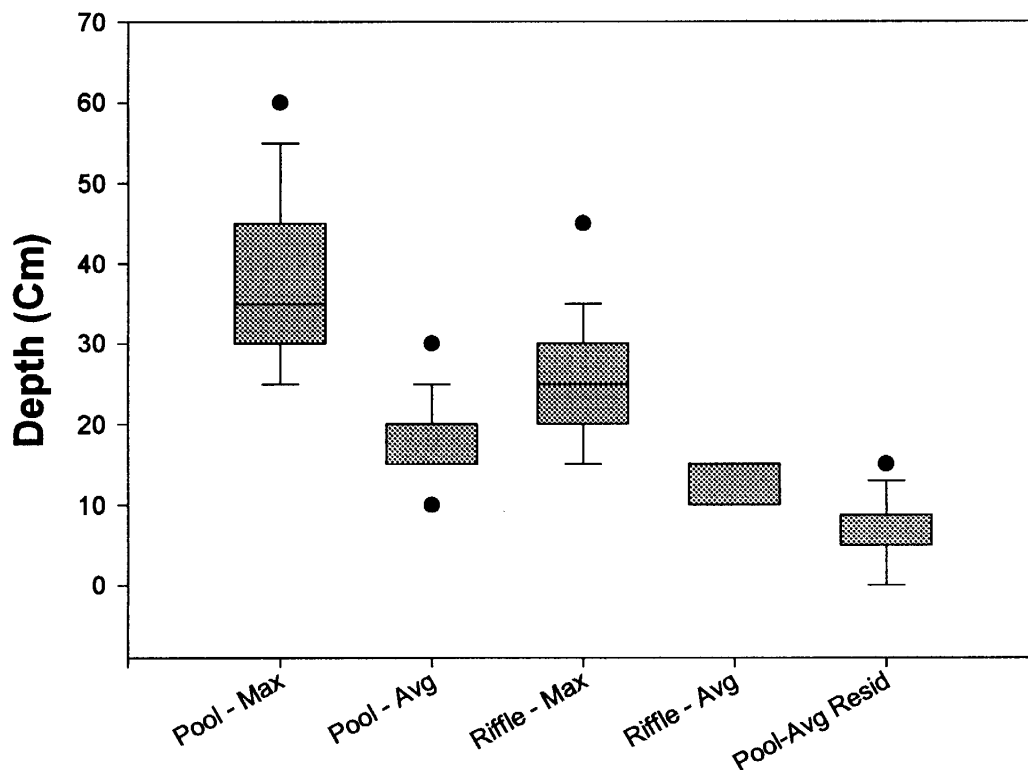


Figure 39. Box plots representing maximum and average depths for pools and riffles, and average residual pool depths for the Long Branch study section. The boxes enclose the middle 50% of the observations, the bar in the center of the boxes represent the median, and the capped lines extending above and below the boxes represent the 90% and 10% quantiles.

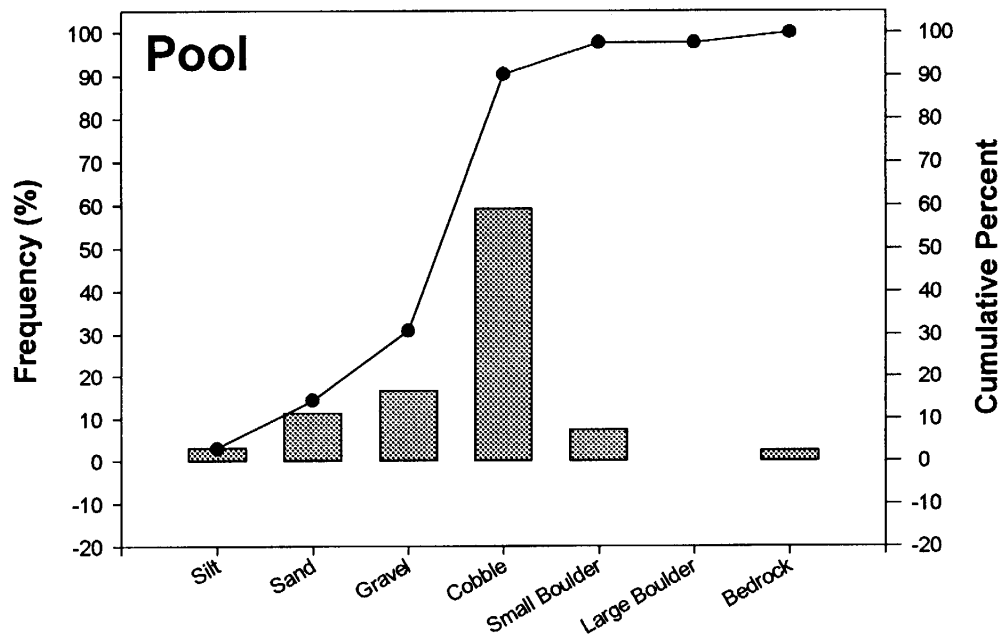


Figure 40. Average corrected estimates of substrate in pools for the Long Branch study section. No confidence intervals were calculated due to only one paired sample.

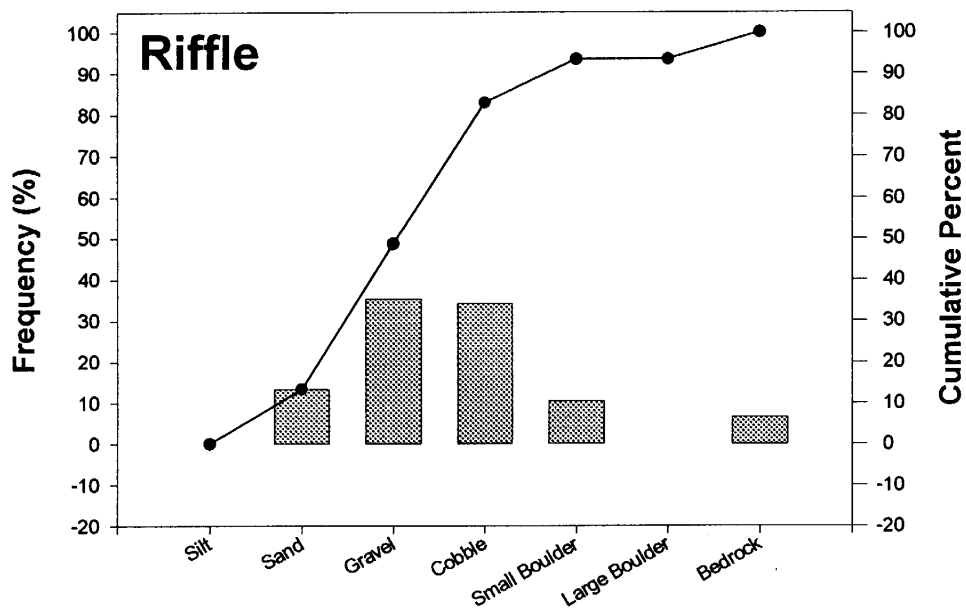


Figure 41. Average corrected estimates of substrate in riffles for the Long Branch study section. No confidence intervals were calculated due to only one paired sample.

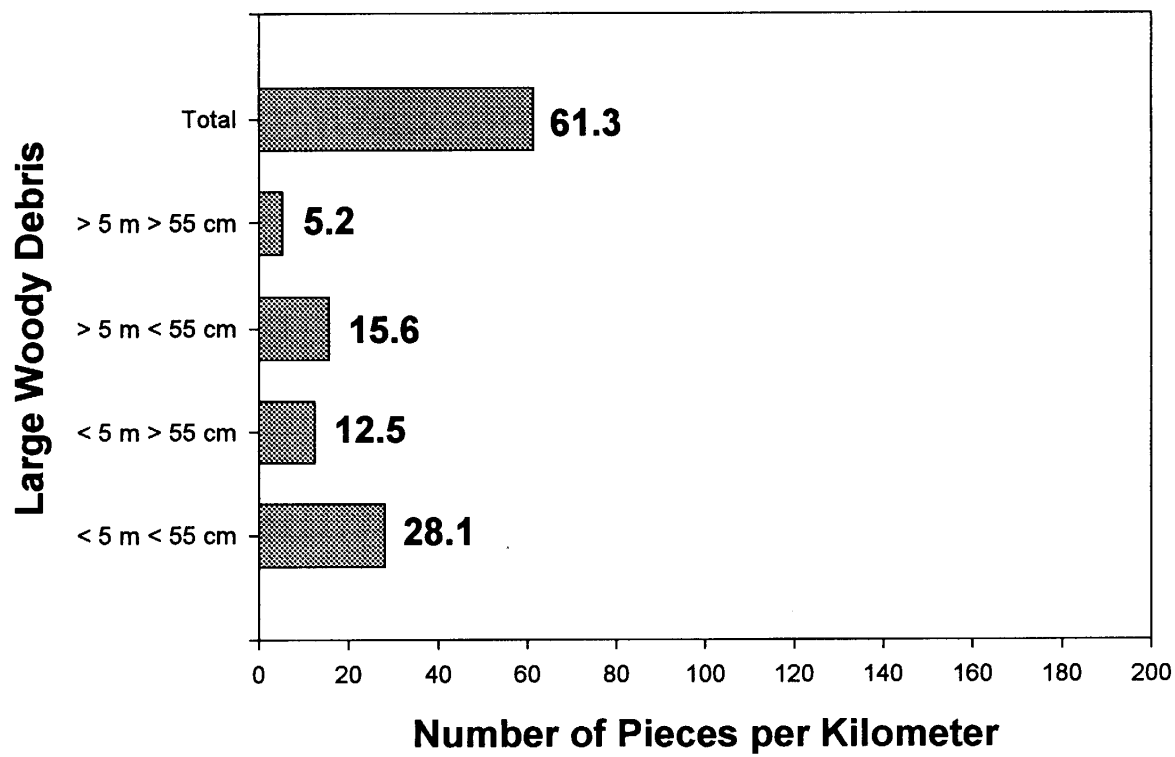


Figure 42. Pieces of large woody debris per mile in the Long Branch study section.

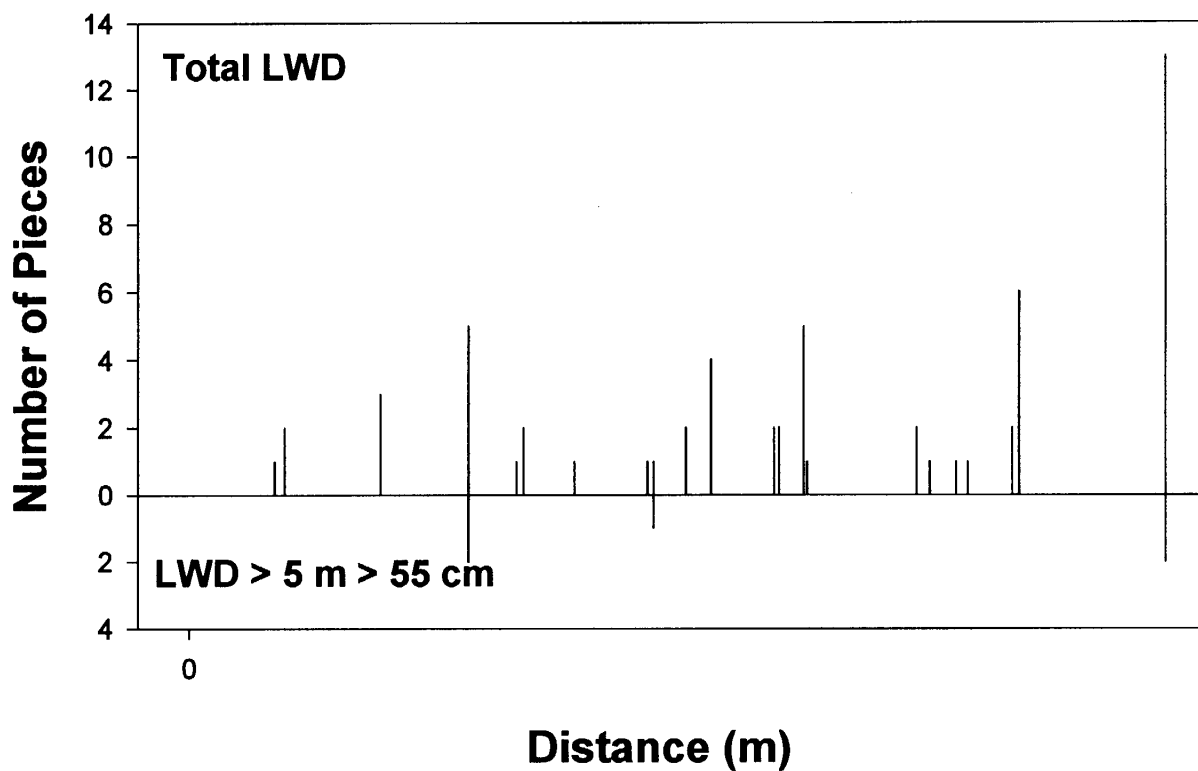


Figure 43. Distribution and total abundance of large woody debris in the Long Branch study section.

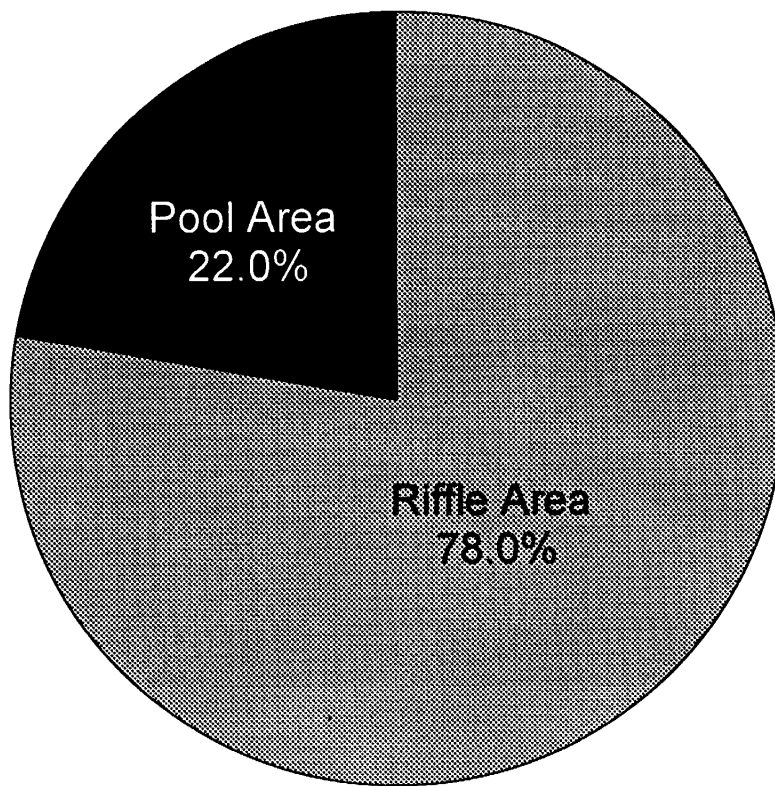


Figure 44. Percent pool and riffle area present in the Devils Prong study section.

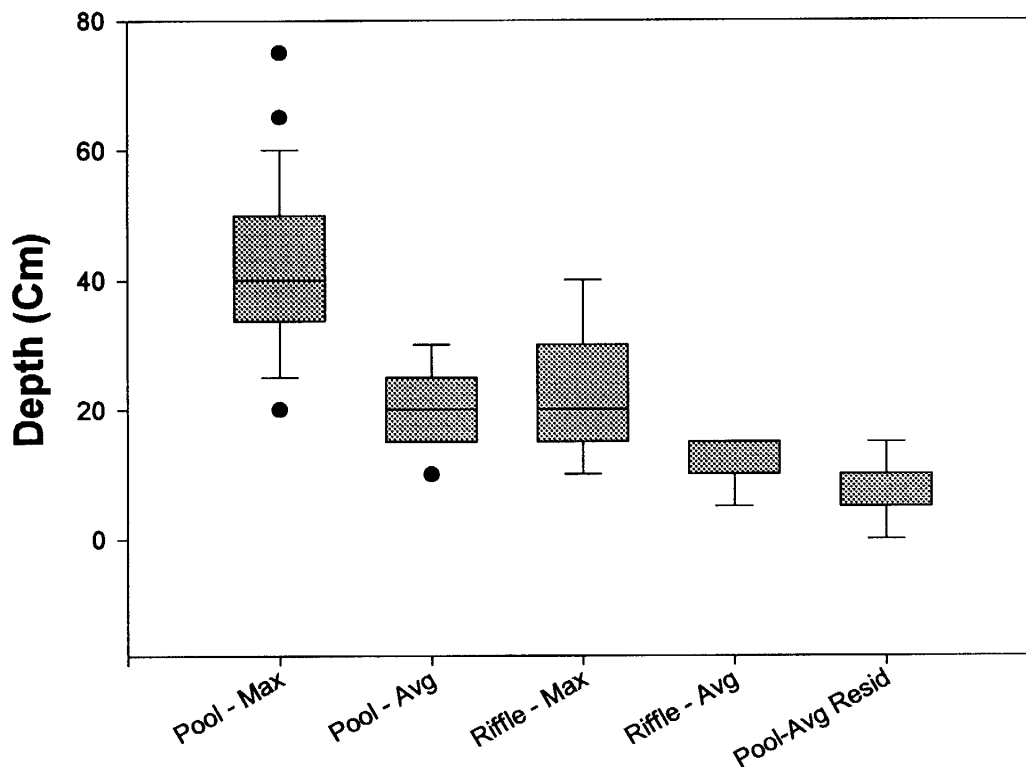


Figure 45. Box plots representing maximum and average depths for pools and riffles, and average residual pool depths for the Devils Prong study section. The boxes enclose the middle 50% of the observations, the bar in the center of the boxes represent the median, and the capped lines extending above and below the boxes represent the 90% and 10% quantiles.



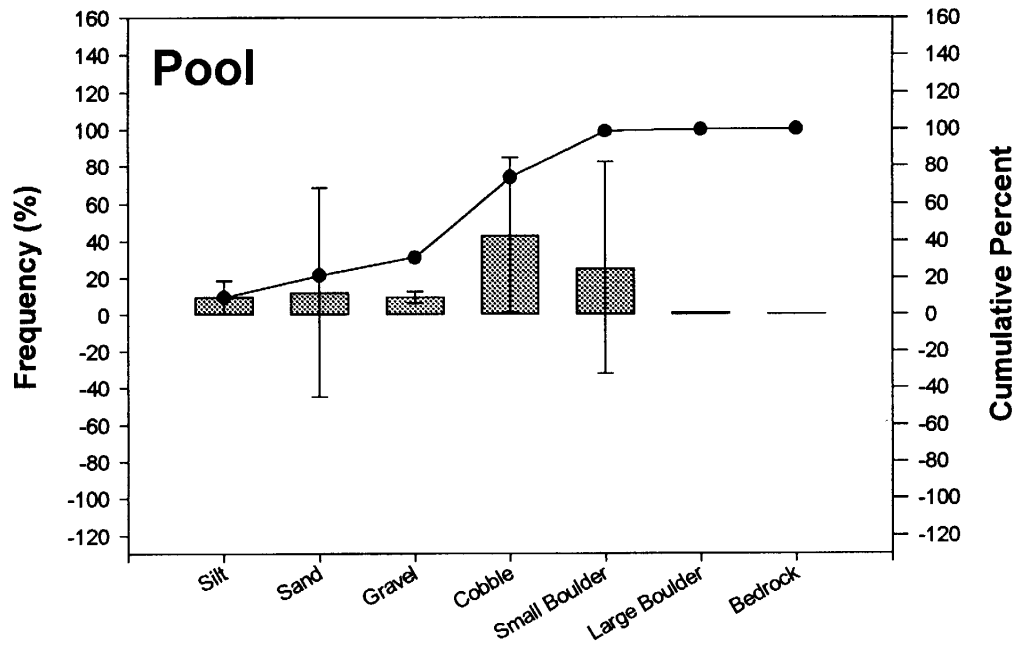


Figure 46. Average corrected estimates of substrate in pools for the Devils Prong study section.

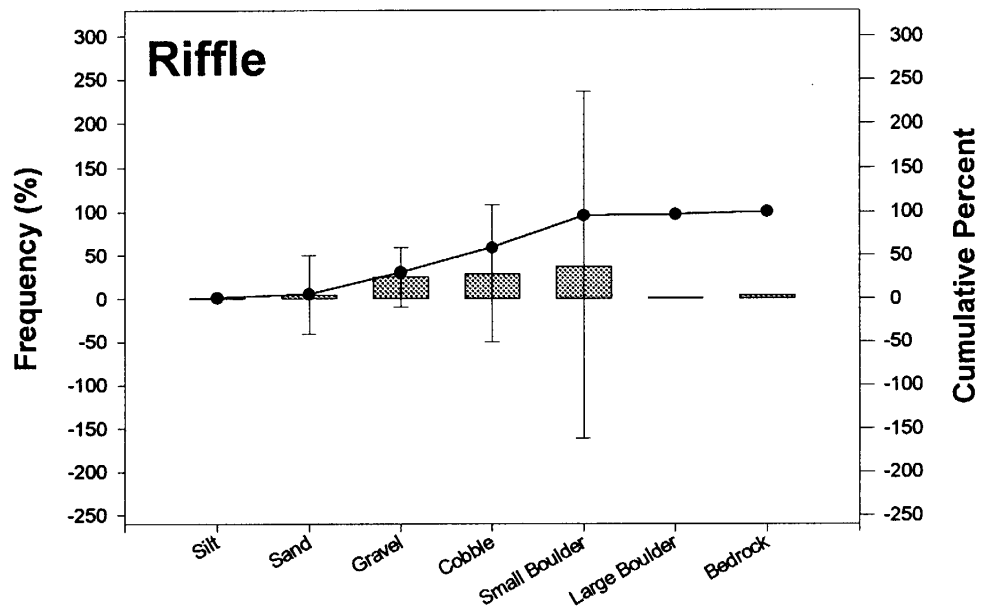


Figure 47. Average corrected estimates of substrate in riffles for the Devils Prong study section.

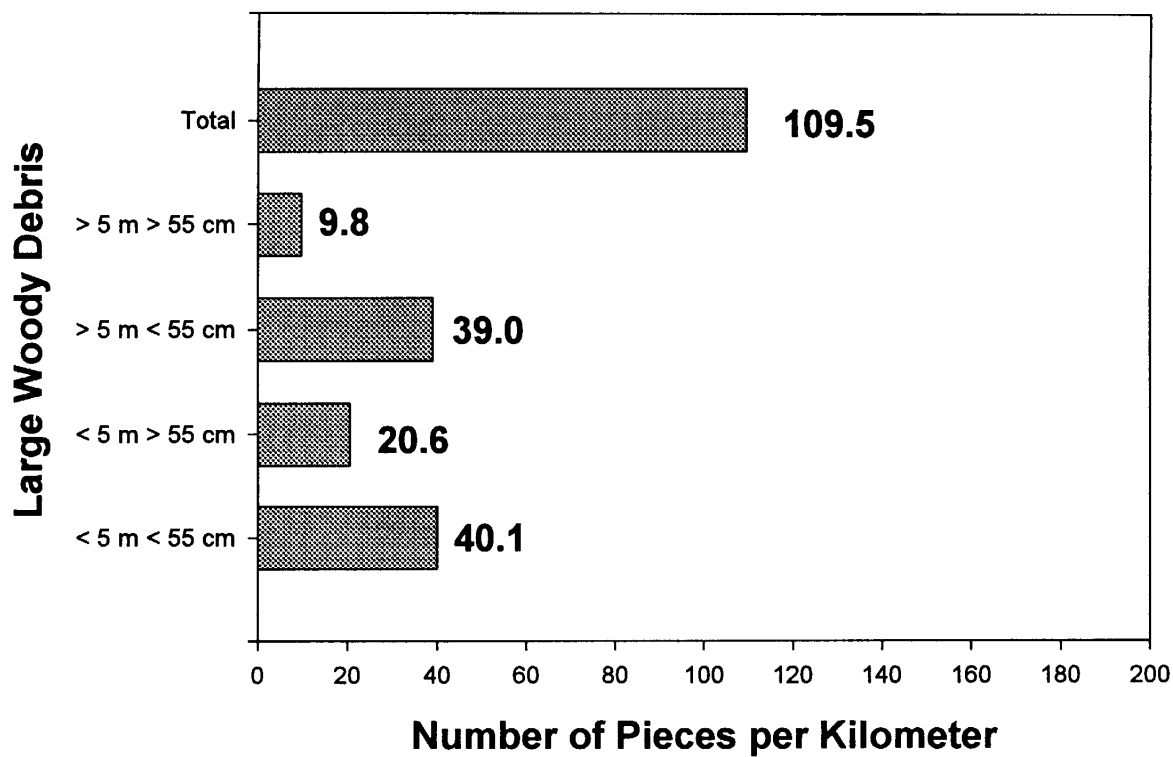


Figure 48. Pieces of large woody debris per kilometer in the Devils Prong study section.

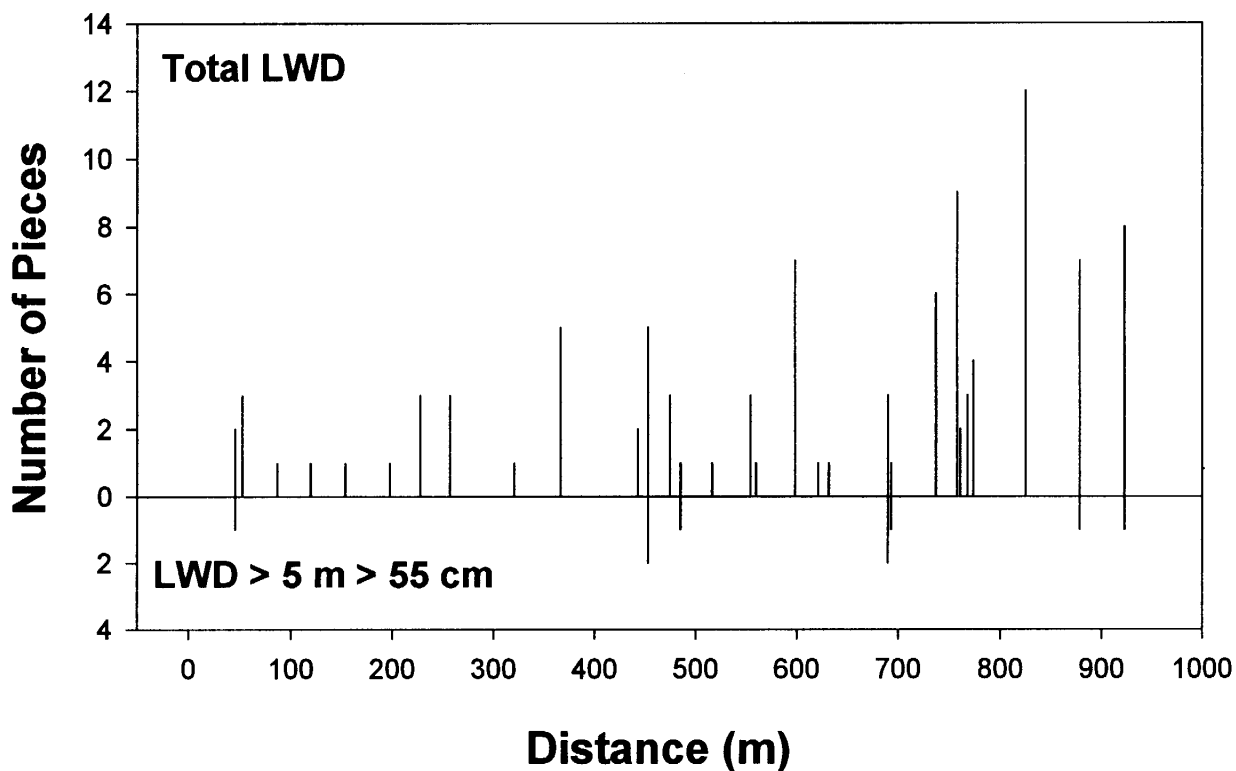


Figure 49. Distribution and total abundance of large woody debris in the Devils Prong study section.

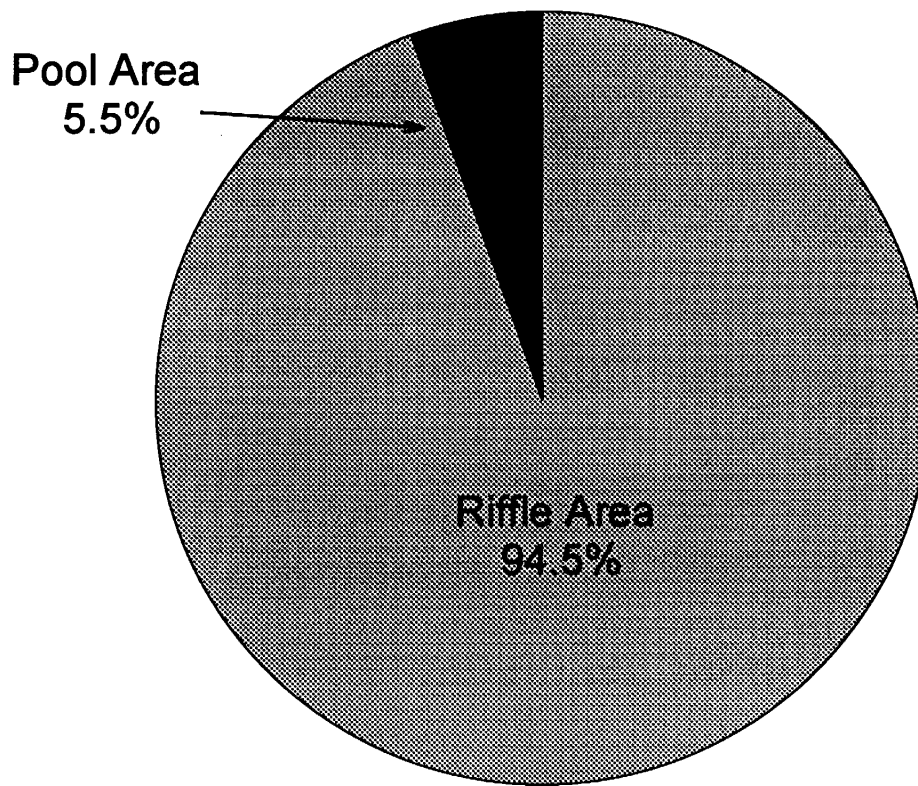


Figure 50. Percent pool and riffle area present in the Little Indian Creek study section.

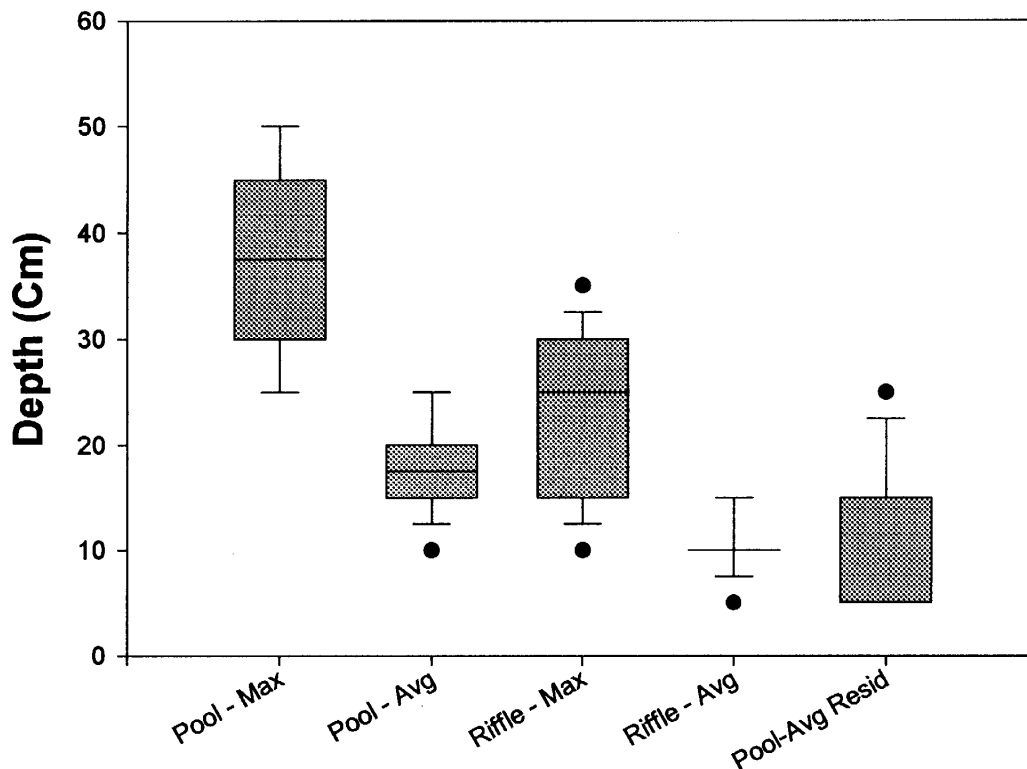


Figure 51. Box plots representing maximum and average depths for pools and riffles, and average residual pool depths for the Little Indian Creek study section. The boxes enclose the middle 50% of the observations, the bar in the center of the boxes represent the median, and the capped lines extending above and below the boxes represent the 90% and 10% quantiles.

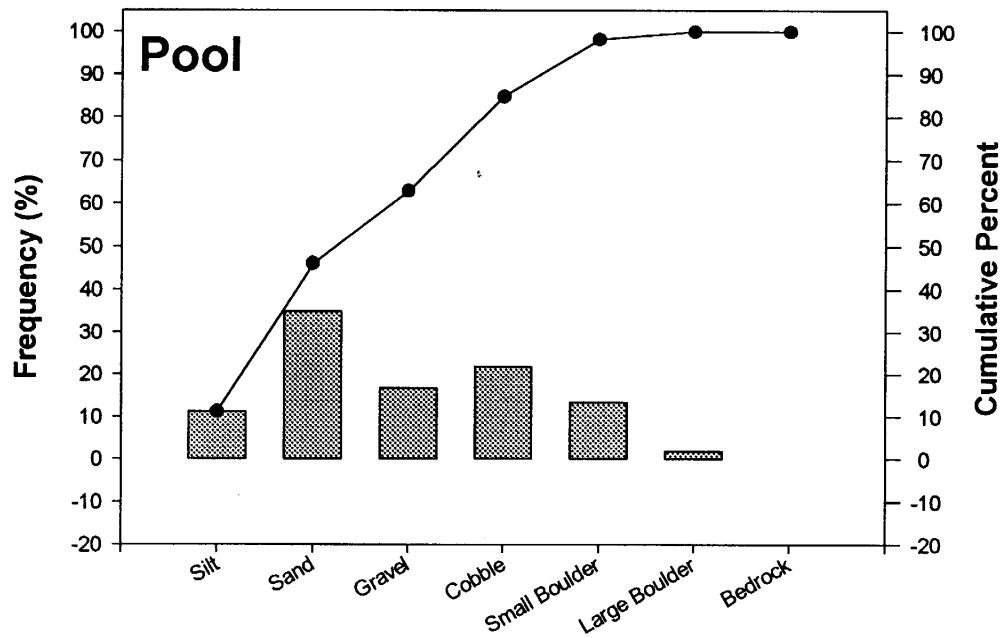


Figure 52. Average corrected estimates of substrate in pools for the Little Indian Creek study section. No confidence intervals calculated due to only one paired sample.

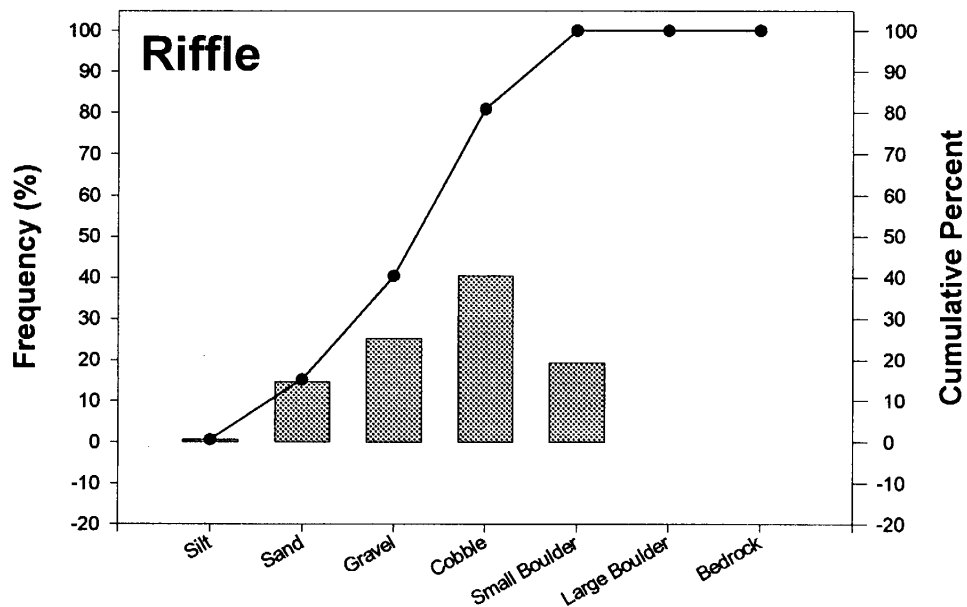


Figure 53. Average corrected estimates of substrate in riffles for the Little Indian Creek study section. No confidence intervals calculated due to only one paired sample.

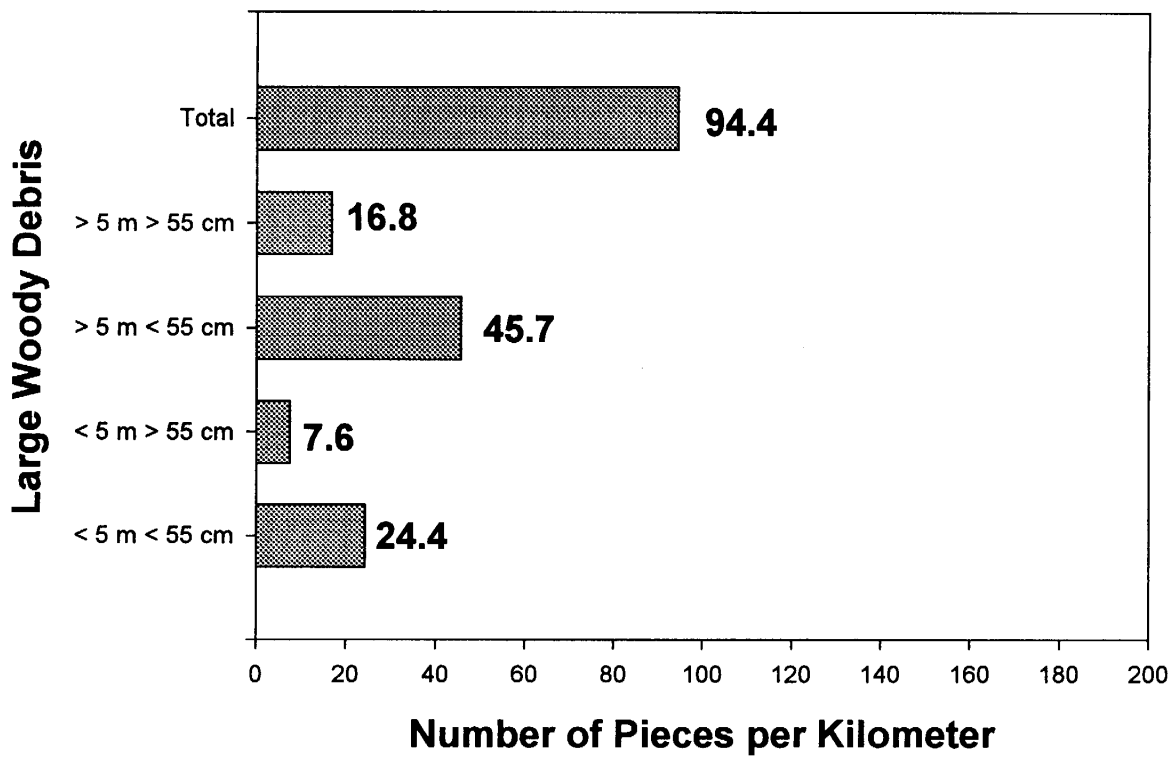


Figure 54. Pieces of large woody debris per kilometer in the Little Indian Creek study section.

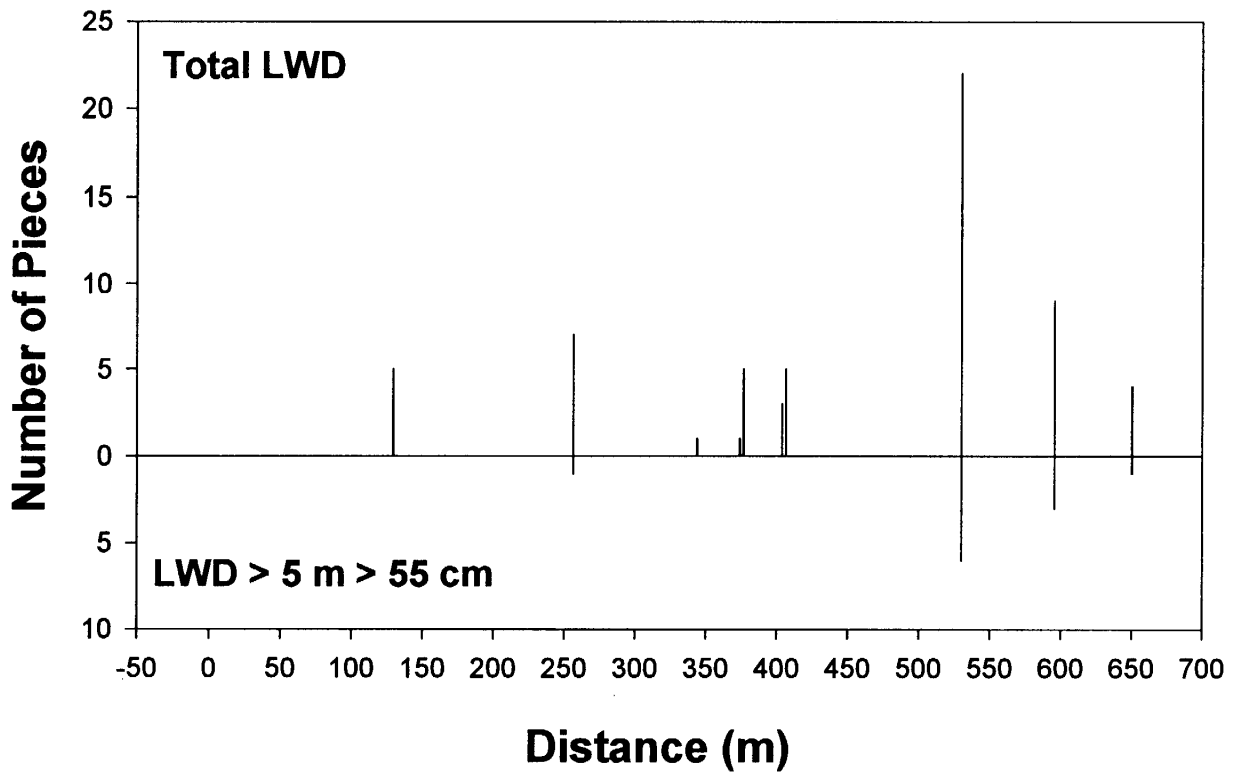


Figure 55. Distribution and total abundance of large woody debris in the Little Indian Creek study section.

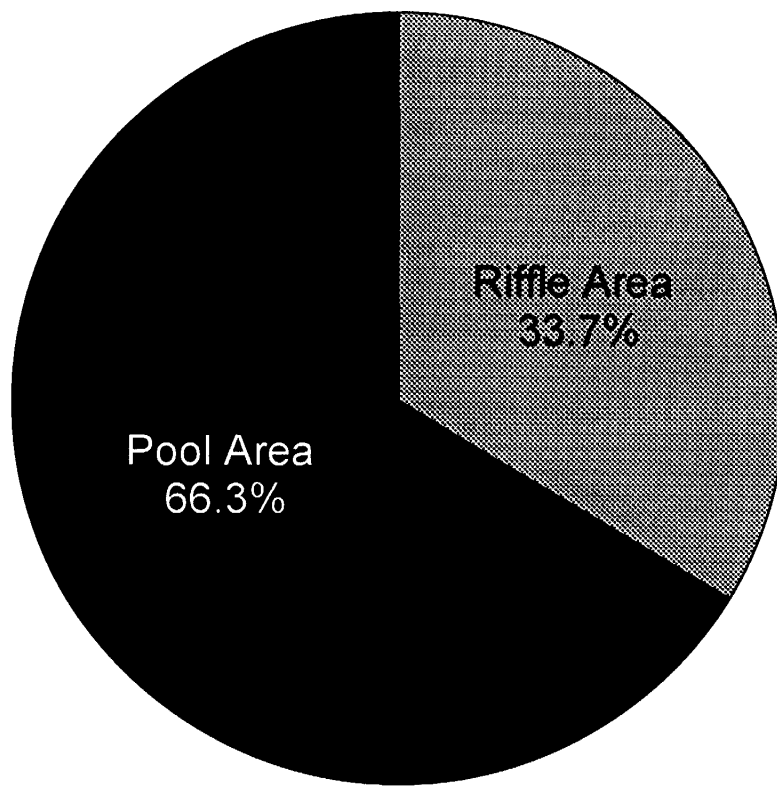


Figure 56. Percent pool and riffle area present in the Yellow Patch Branch study section.

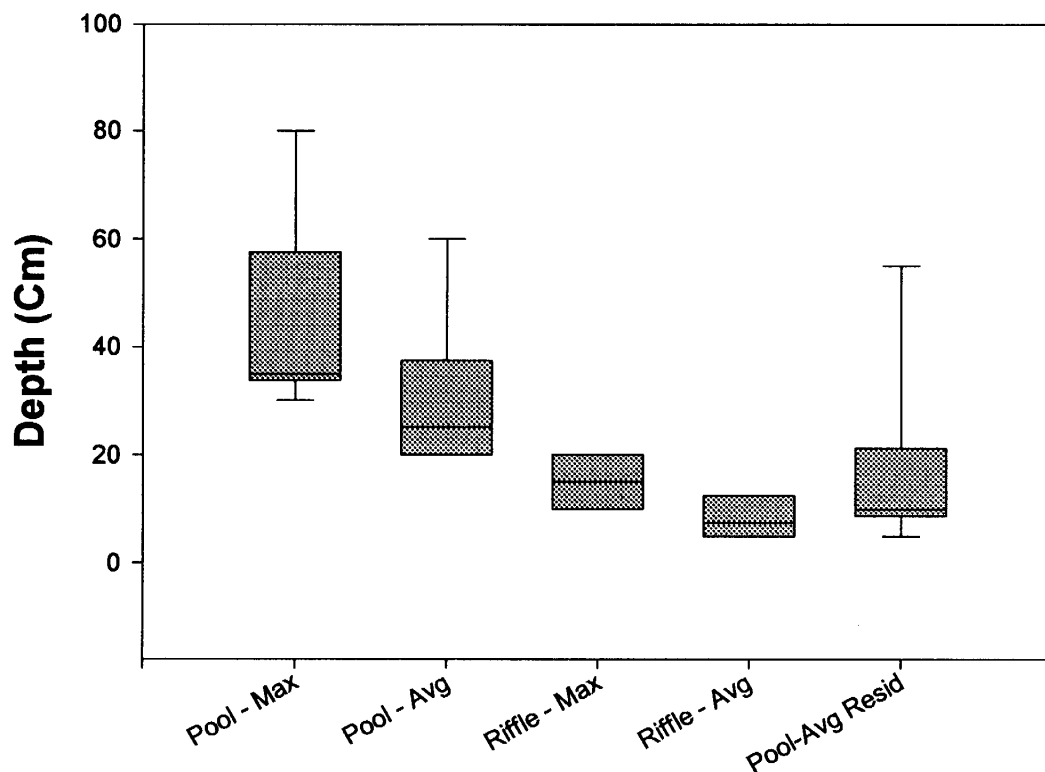


Figure 57. Box plots representing maximum and average depths for pools and riffles, and average residual pool depths for the Yellow Patch Branch study section. The boxes enclose the middle 50% of the observations, the bar in the center of the boxes represent the median, and the capped lines extending above and below the boxes represent the 90% and 10% quantiles.

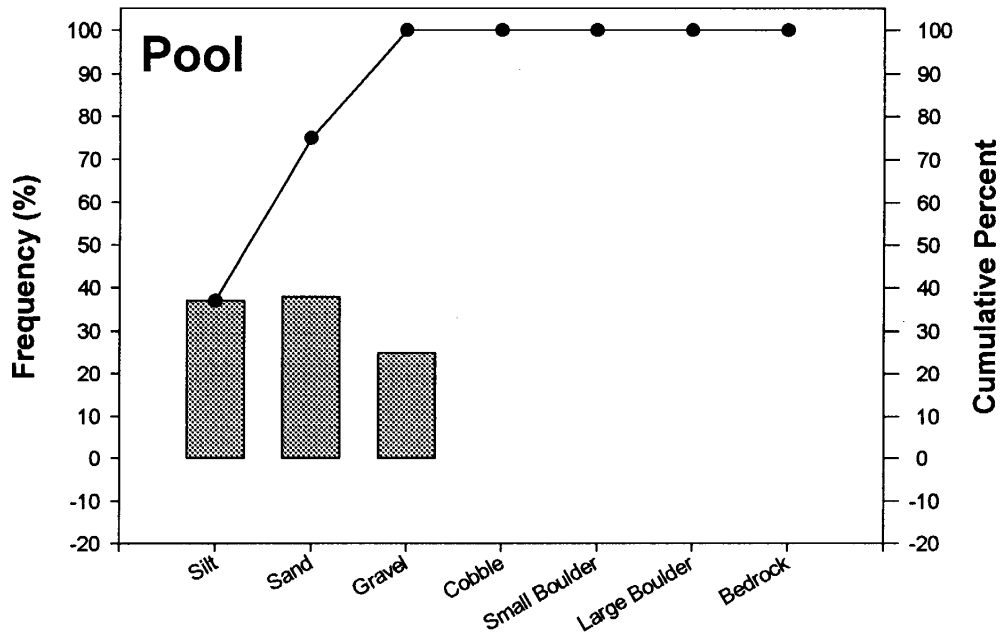


Figure 58. Average corrected estimates of substrate in pools for the Yellow Patch Branch study section. No confidence intervals could be calculated due to no paired samples.

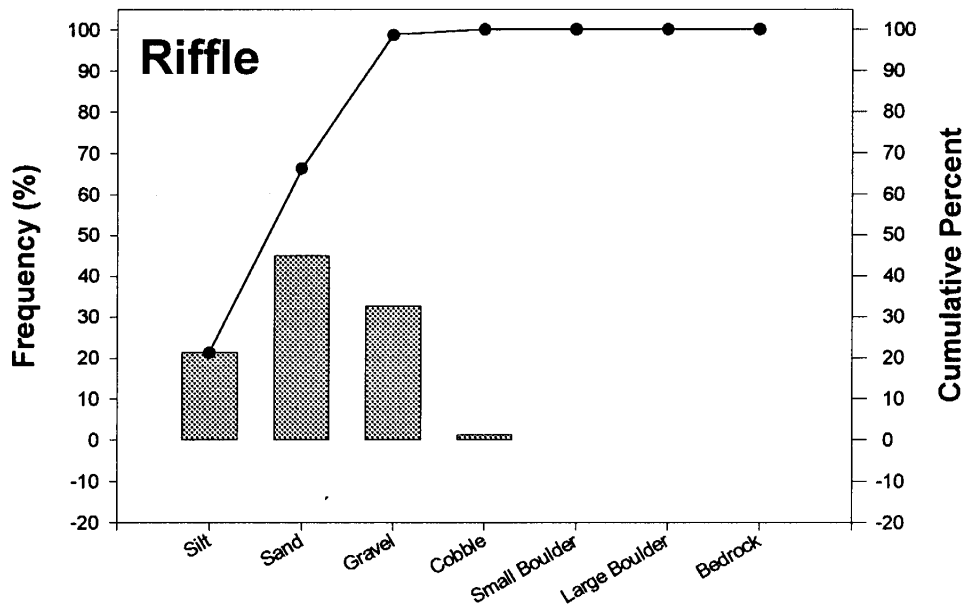


Figure 59. Average corrected estimates of substrate in riffles for the Yellow Patch Branch study section. No confidence intervals could be calculated due to no paired samples.

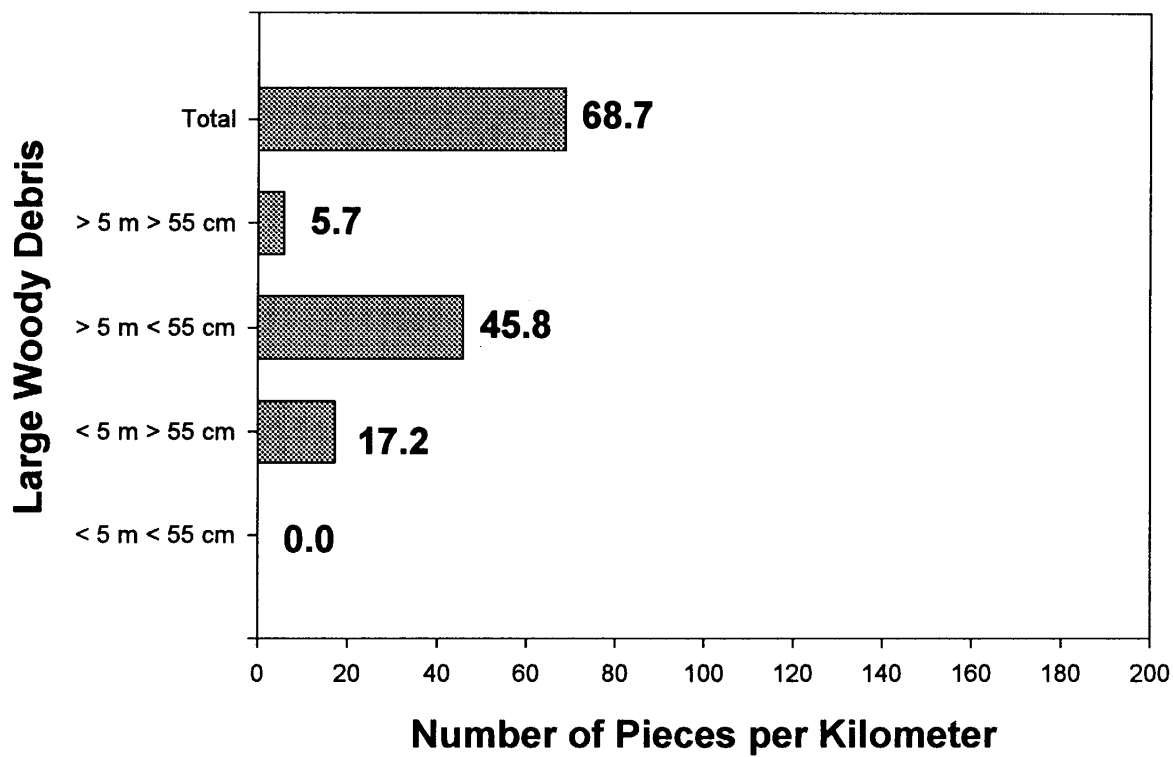


Figure 60. Pieces of large woody debris per kilometer in the Yellow Patch Branch study section.

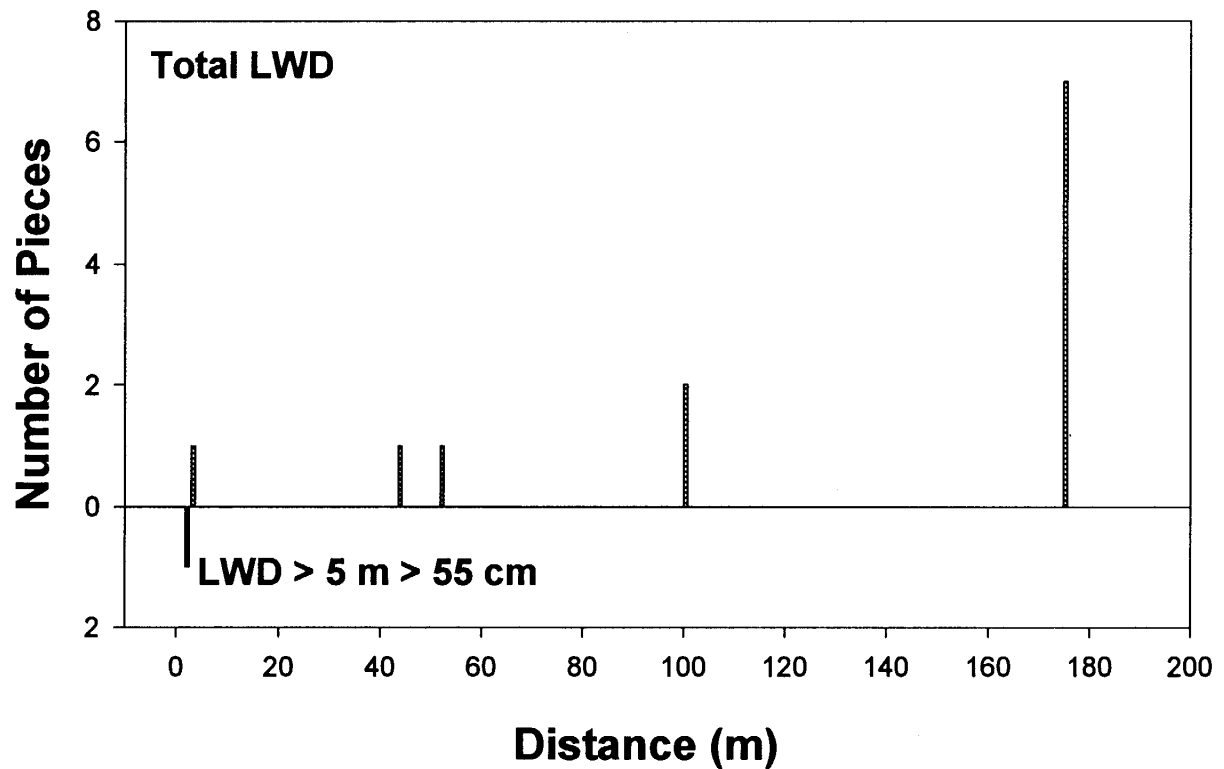


Figure 61. Distribution and total abundance of large woody debris in the Yellow Patch Branch study section.